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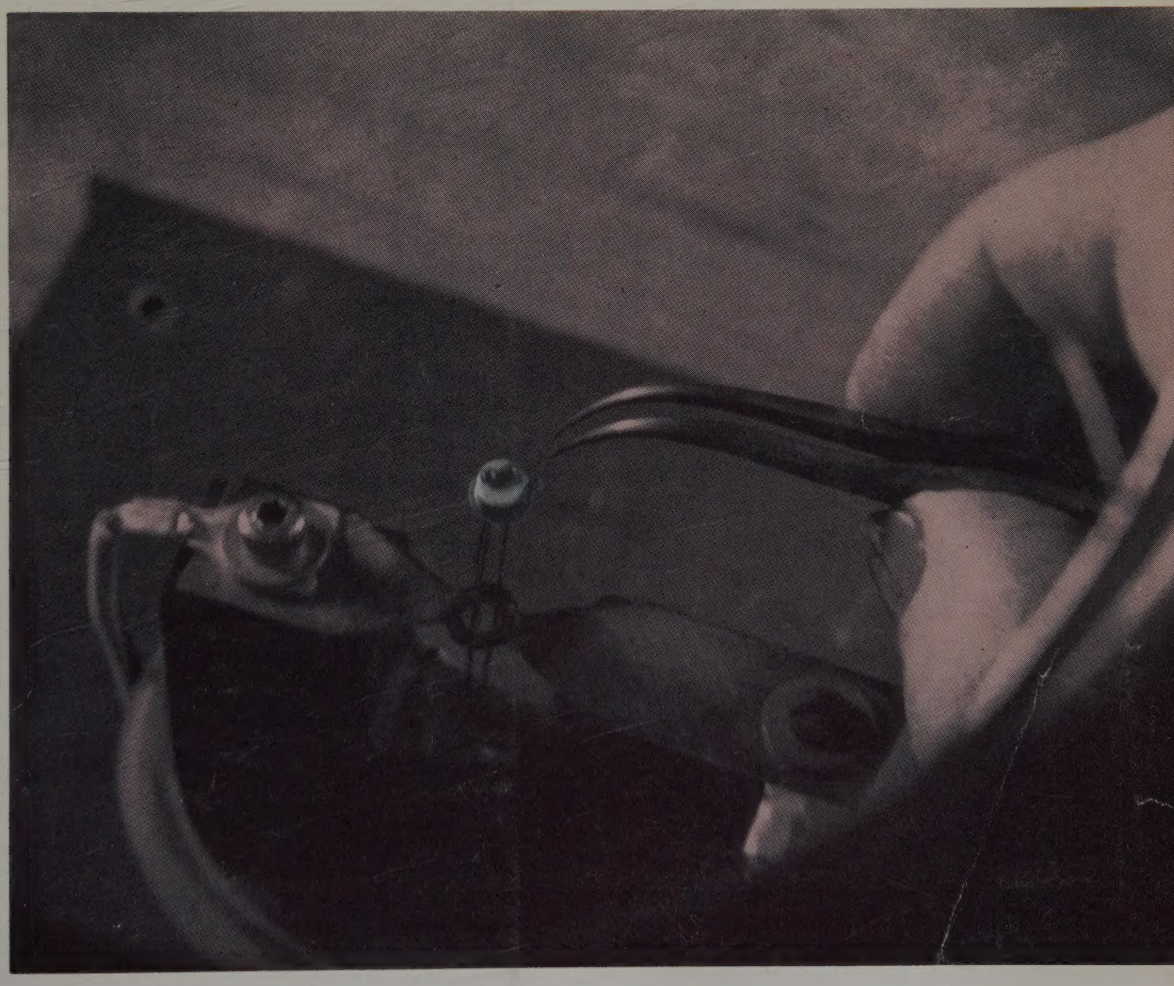
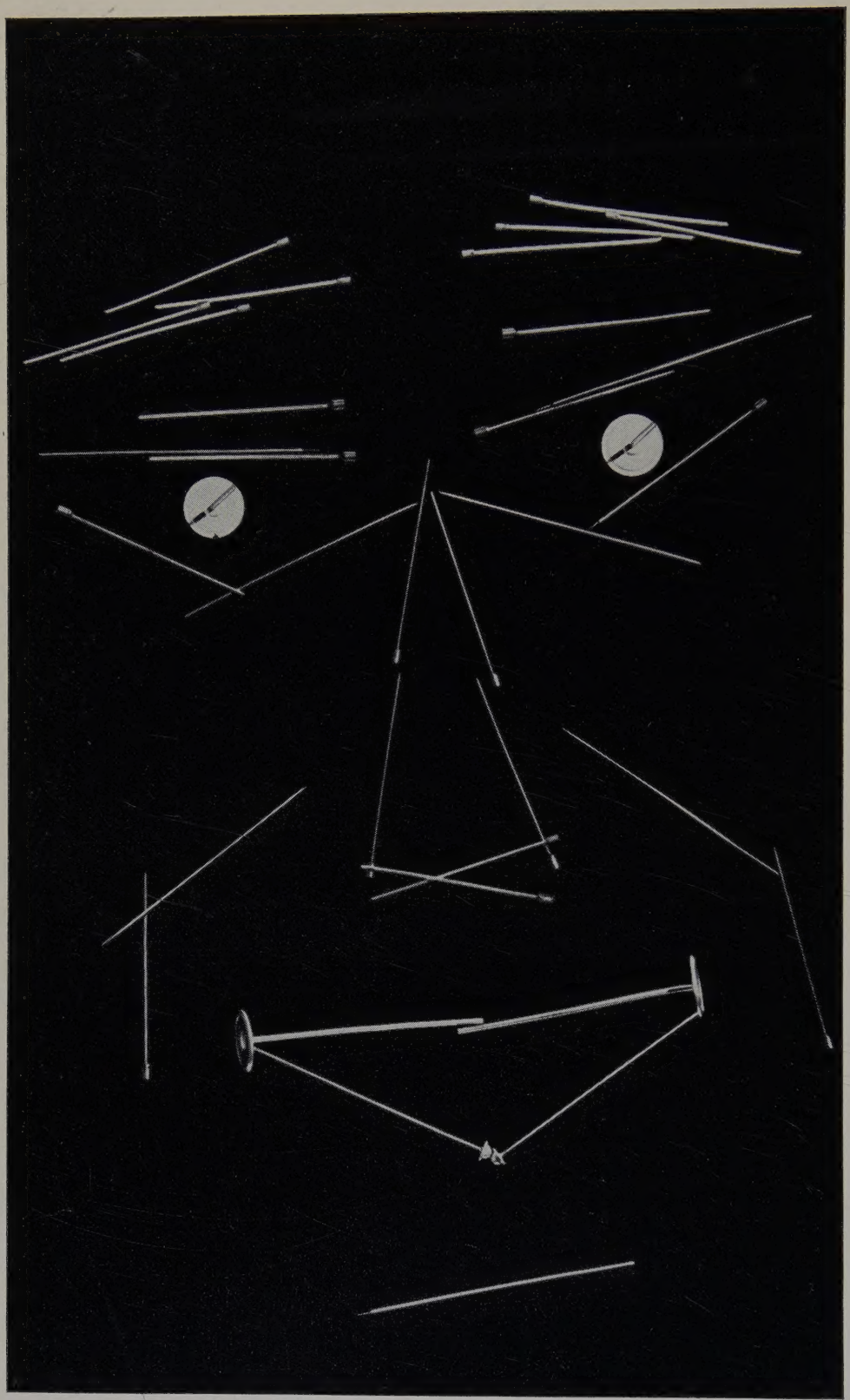
EMICONDUCTOR PRODUCTS

Tunnel diode tab with triangular configuration



Design of Transistorized Auto Radio Receivers
Temperature Control of Silicon Solar Cells
Survey of Tunnel Diodes



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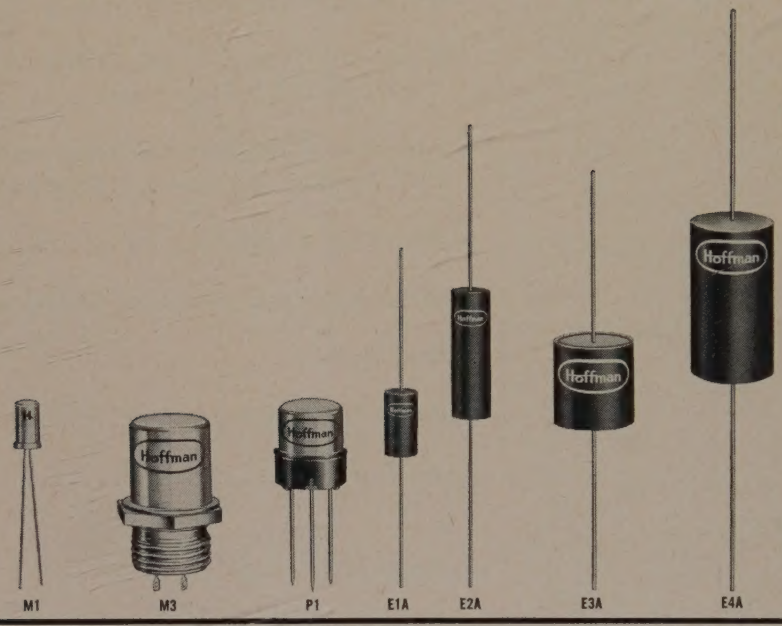

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JEDEC TYPE NO.	CASE TYPE	OPERATING VOLTAGE AT 10mA AND 25°C (VOLTS)	MAXIMUM CHANGE IN OPERATING VOLTAGE OVER TEMP. RANGE —55°C TO 25°C AND 25°C TO 100°C	MAXIMUM DYNAMIC IMPEDANCE AT 10mA AND 25°C (OHMS)
* 1N429	M1	5.9 (Min.) 6.5 (Max.)①	±0.05 ①	20①
* 1N430	M3	8.0 (Min.) 8.8 (Max.)	±0.014	15
1N430A	M3	8.0 (Min.) 8.8 (Max.)	±0.007	15
1N430B	M3	8.0 (Min.) 8.8 (Max.)	±0.011②	15
1N1530	P1	8.0 (Min.) 8.8 (Max.)	±0.014	15
1N1530A	P1	8.0 (Min.) 8.8 (Max.)	±0.007	15

① Operated at 7.5mA and 25°C ②±0.007 (—55°C to +25°C) ± .0011 (+25°C to +150°C)

* USN-1N430 meets requirements of MIL-E-1/1060. USAF-1N429, MIL-E-1/1134A.

SILICON ZENER DECADE REFERENCE UNITS—15 TYPES

JEDEC TYPE NO.	CASE TYPE	OPERATING VOLTAGE AT 7.5mA AND 25°C (VOLTS)	MAXIMUM CHANGE IN OPERATING VOLTAGE OVER TEMP. RANGE —55°C TO 25°C AND 25°C TO 100°C	MAXIMUM DYNAMIC IMPEDANCE AT 7.5mA (OHMS)
1N1735	E1A	6.2 ± 5%	±0.050	20
1N1736	E2A	12.4 ± 5%	±0.100	40
1N1736A	E2A	12.4 ± 5%	±0.050	40
1N1737	E3A	18.6 ± 5%	±0.150	60
1N1737A	E3A	18.6 ± 5%	±0.075	60
1N1738	E3A	24.8 ± 5%	±0.200	80
1N1738A	E3A	24.8 ± 5%	±0.100	80
1N1739	E4A	31.0 ± 5%	±0.250	100
1N1739A	E4A	31.0 ± 5%	±0.125	100
1N1740	E4A	37.2 ± 5%	±0.300	120
1N1740A	E4A	37.2 ± 5%	±0.150	120
1N1741	E4A	43.4 ± 5%	±0.350	140
1N1741A	E4A	43.4 ± 5%	±0.175	140
1N1742	E4A	49.6 ± 5%	±0.400	180
1N1742A	E4A	49.6 ± 5%	±0.200	180

1N429: Used to maintain constant DC voltage under conditions of severe shock, vibration, and temperature. Ideal where stability of ±1% or better is specified over temperature range of —55°C to +100°C. 1N430 SERIES: Ideal where stability of ±0.2% or ±0.1% required. 1N1530, 1N1530A: Electrically equivalent to 1N430 and 1N430A, but intended for printed circuit use.

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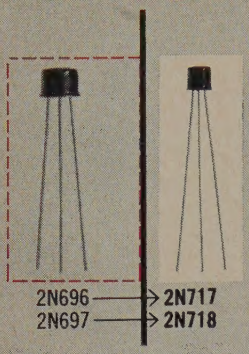

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SANFORD R. COWAN, Publisher

June 1960 Vol. 3 No. 6

CONTENTS

Editorial 27

Transistorized Automobile Receivers Employing Drift Transistors, *by Richard A. Santilli and C. Frank Wheatley* 29

Esaki or Tunnel Diodes, *(Part II) by Wolfgang W. Gartner* 36

Temperature Control of Silicon Solar Cells in Space Environment, *by Werner Luft and Harry Nash* 39

Application of Transistors to Video Equipment, *(Part II) by K. Hiwatashi, Y. Fujimura, K. Suzuki, and N. Mii* 44

Applications Engineering Digests 49

Semiconductor and Solid State Bibliography 52

Patent Review 55

New Diode & Rectifier Charts 57

Correction 35

Departments

Book Reviews 15
New Products 61
Industry News 66
Market News 72
New Literature 75
Personnel Notes 77

Advertisers' Index 79

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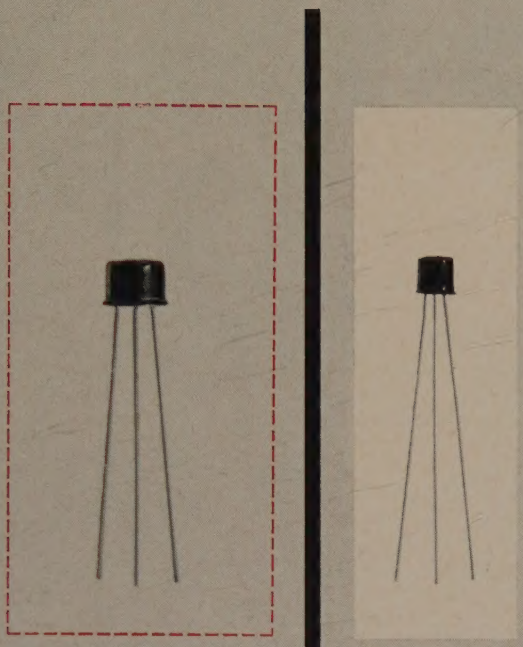
Front Cover

The development by engineers of Philco Corporation's Lansdale Division of a new technique for mounting a tunnel diode tab of triangular configuration has effected a low series inductance of one millimicrohenry and a low series resistance of one ohm, both characteristics being typical.



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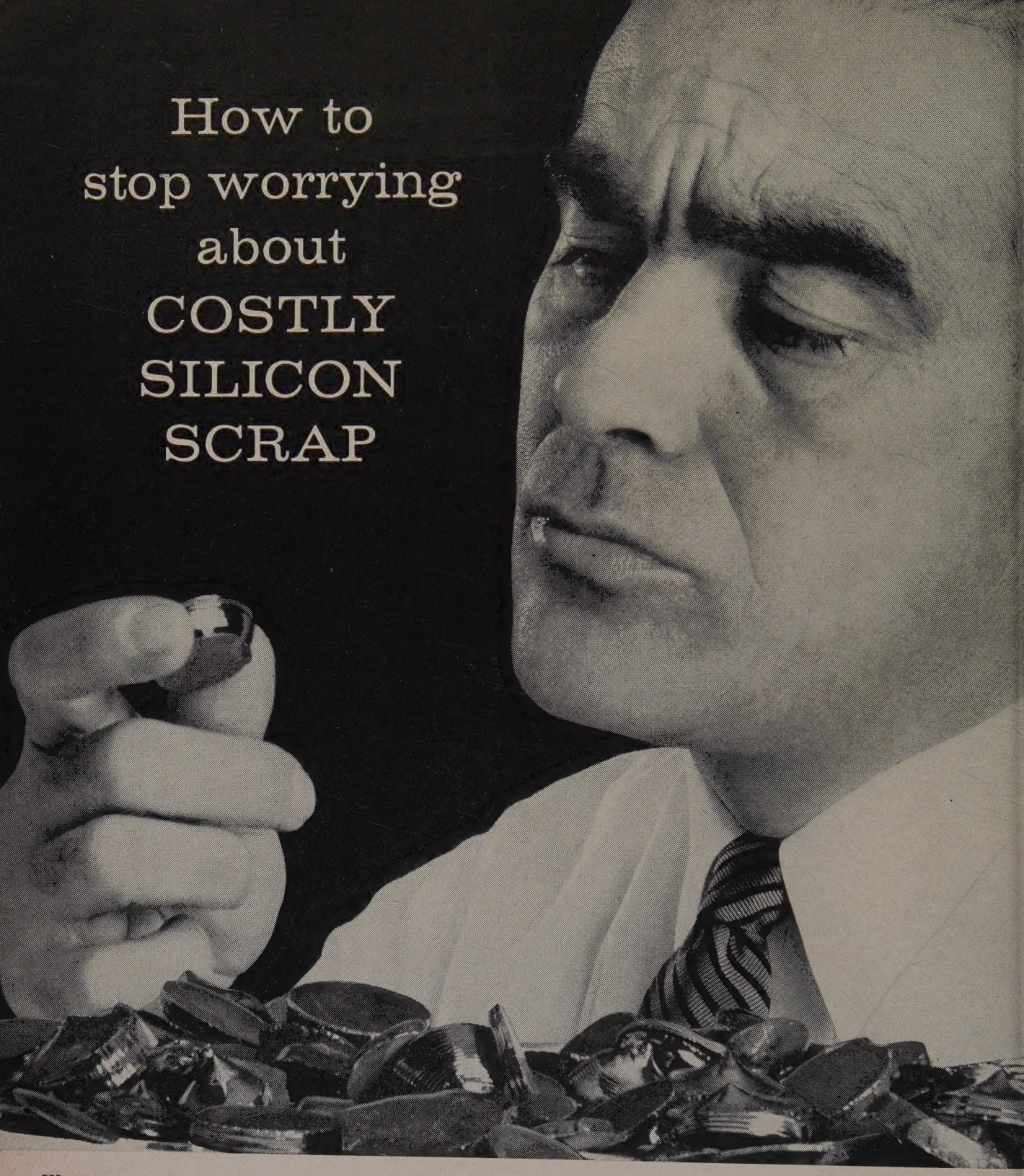

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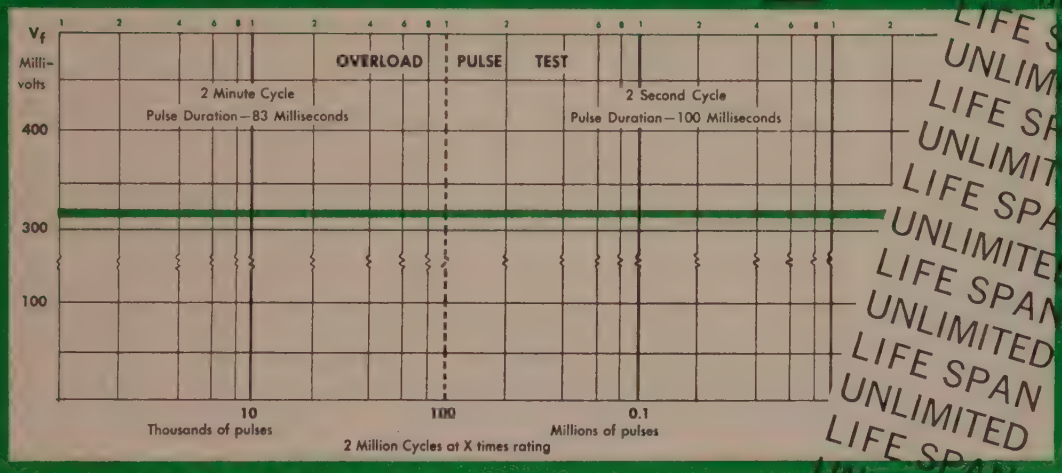

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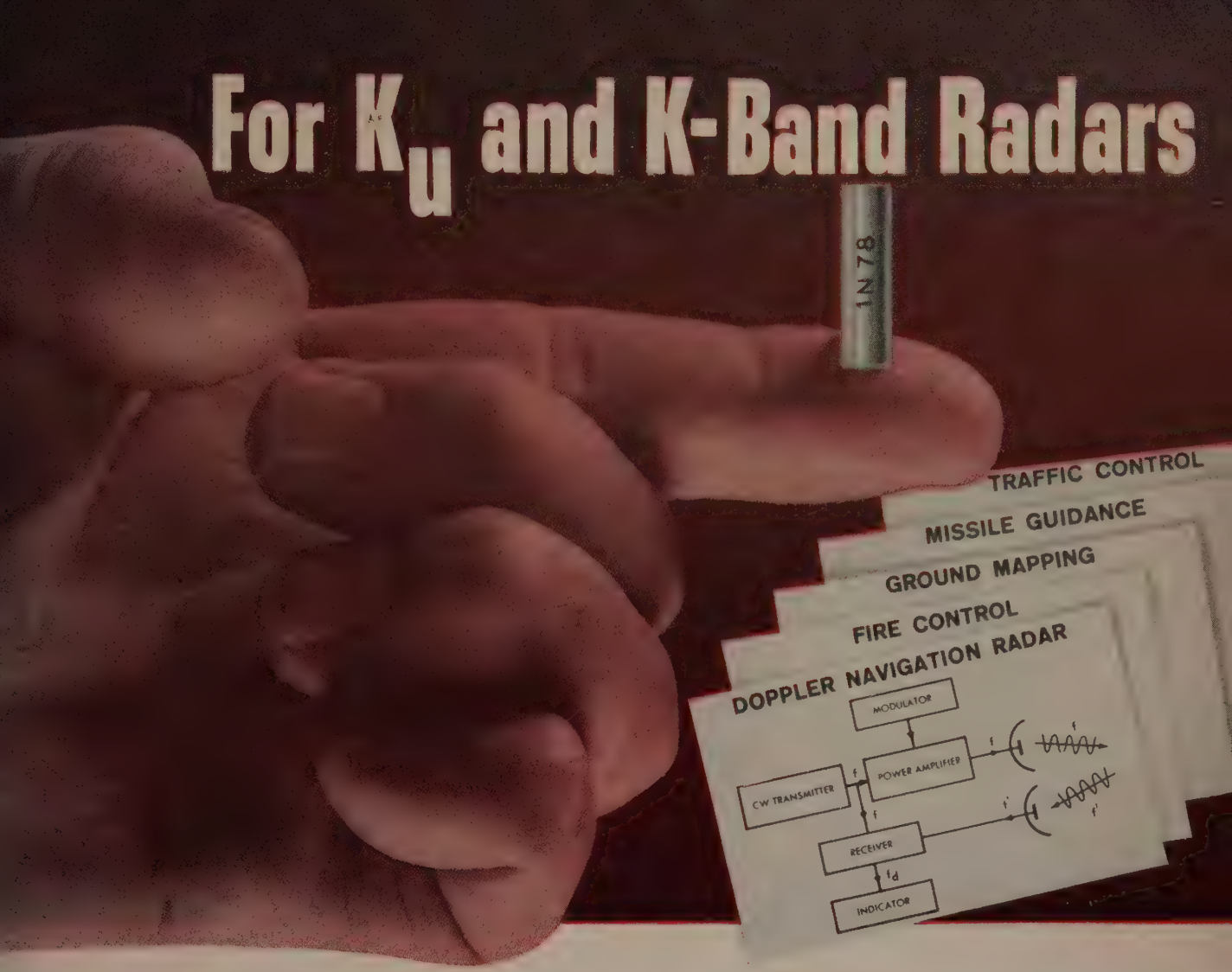

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Over-all Receiver Noise	13.1	11.3	10.0	(db)

	1N78	1N78A	1N78B	1N78C	1N78D	
Conversion Loss	7.5	7.0	6.5	6.0	5.7	(db)
Noise Ratio	2.5	1.5	1.3	1.3	1.3	(times)
RF Impedance	—	1.6	1.6	1.5	1.5	(VSWR)
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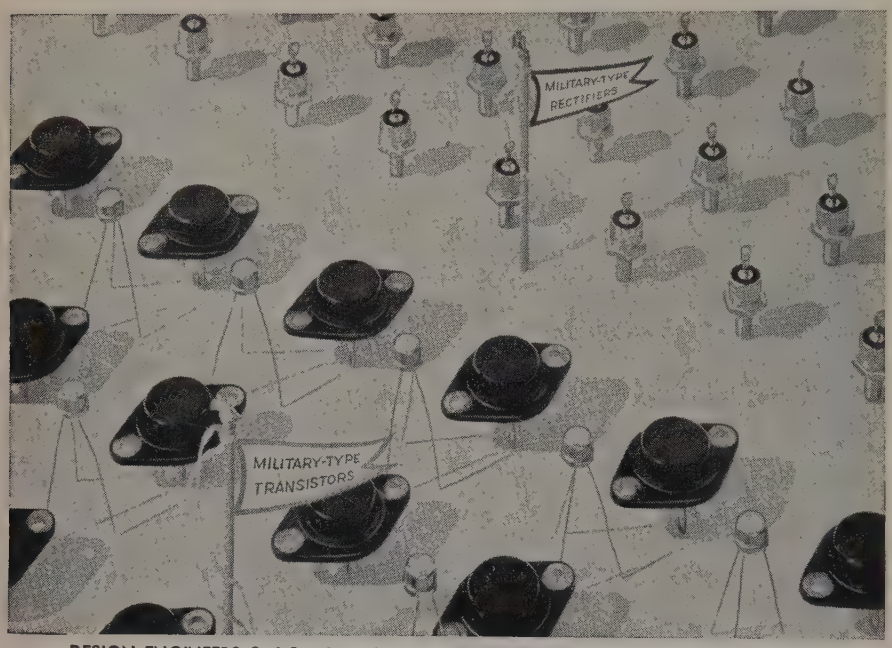

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		Vce Vdc	Vcb Vdc	Ic Adc	Pc W	Tj °C	T storage °C	h_{FE} at Ic Adc	
2N297A	/36A (SigC)	−50	−60	5	35	95	−65 to +95	70	0.5
2N331	/4A	−12	−30	0.2	0.075	85	−65 to +85	50	0.001
2N1011	/67 (Sig C)	−70	−80	5	35	95	−65 to +95	55	3.0
2N1120	/68 (Sig C)	−70	−80	10	45	95	−65 to +95	35	10.0

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1N1615	/1241	5 Adc	400	50 μAdc	280	750 μAdc
1N1616	/1242	5 Adc	600	50 μAdc	420	750 μAdc

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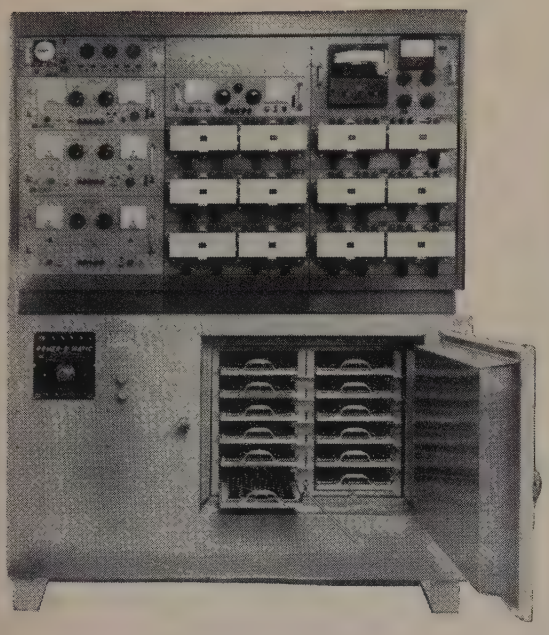
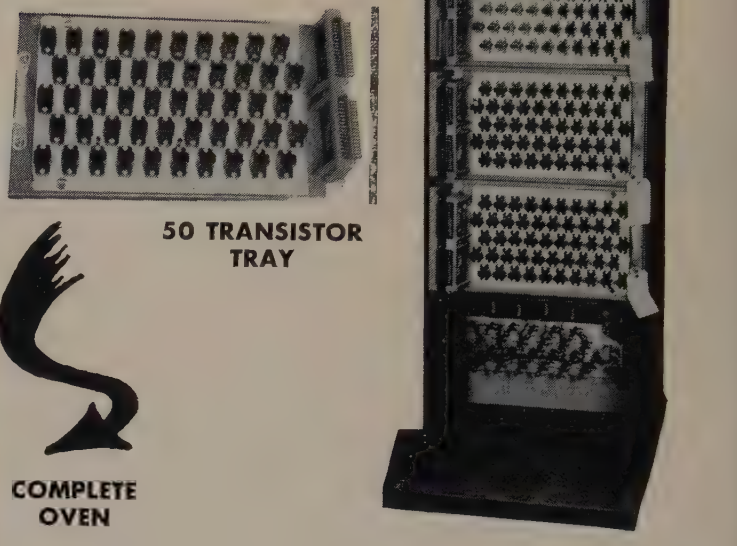
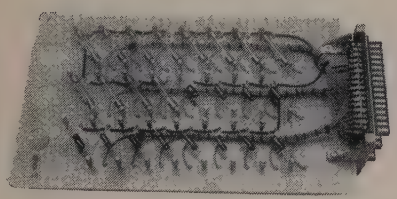


AMBIENT TEMPERATURE RACK



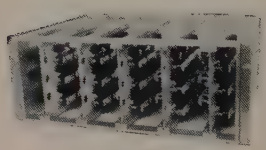
50 TRANSISTOR TRAY

COMPLETE OVEN

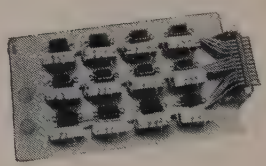


PLUG-IN CIRCUITRY

RELAY RACK MODULE



ILLUSTRATED ABOVE ARE EXAMPLES OF TRANSISTOR LIFE TEST EQUIPMENT MANUFACTURED BY AEROTRONIC FOR MAJOR SEMICONDUCTOR MANUFACTURERS.



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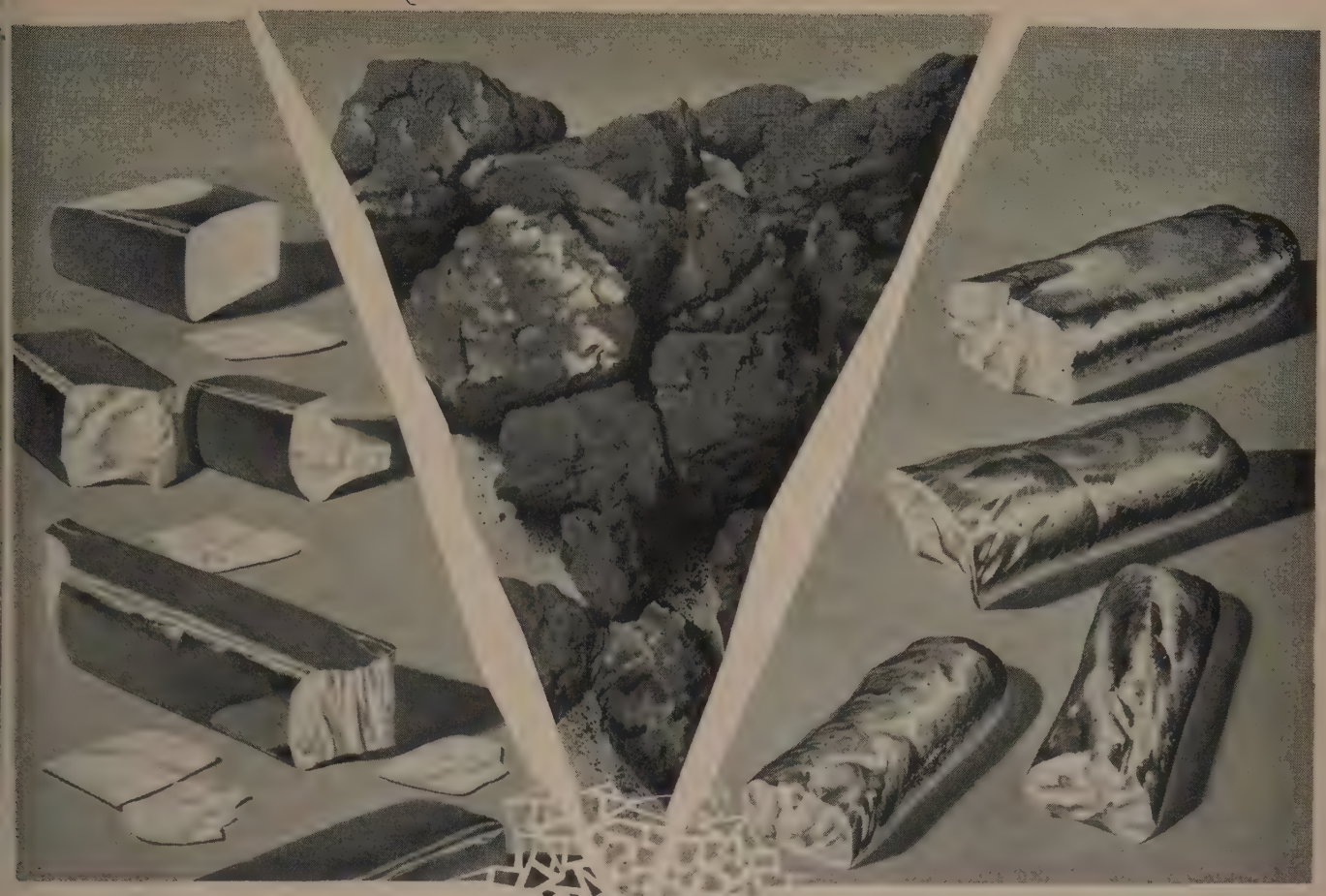

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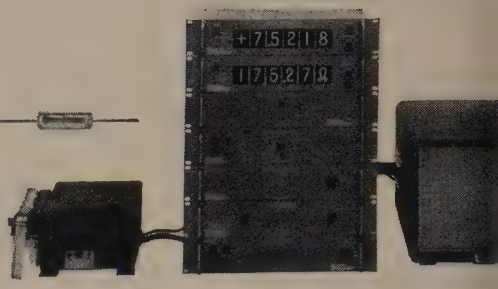

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what happens when you place a lighted match beneath ece of Alpha coated strip. Notice that, even when liquid, strip's Continuous Conductive Coating* clings to the e metal in a smooth, uniform layer.

Next, using a bit of sandpaper, try removing the solder ting... Observe that coating and base have not sepa- ed during the heating operation. The reason? Alpha's ntinuous Conductive Coating process insures a *perma- nt, metallurgical bond* between the solder and base metal! As a result, for the first time, it is possible to produce ated strip with the following unique advantages:

1. **Coatings ranging in thickness** from .0005" to .004" can be applied.
2. **These coatings can be added** to the base metal's *entire* surface or just a *part* of it. This latter feature frees one or both ends of the tab for welding to the base lead without the danger of solder splatter!
3. **The base metal** can be supplied in all tempers.
4. **A large variety of alloys** containing n or p type dopants can be applied to a wide range of base materials.

Another advantage of this process is that it produces a uniform coating thickness. This is an important feature in safeguarding alignment of the dice on the base tabs, low electrical resistance and reliable mechanical stability. As a result, you enjoy better in-process control of base tab soldering; *positive ohmic contact is assured!*

See if you don't agree that Alpha coated strip can cut your semiconductor device costs. Make the match test. Write for samples of Alpha coated strip. We'll also send you free Alpha Technical Bulletin No. 107, "Alloy Coated Metals." Act now!

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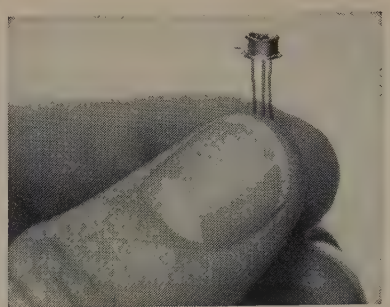

New developments in Esaki Diode technology at IBM

The Esaki Diode at left was made experimentally.

Soon after the original discovery of the Esaki Diode, IBM engineers and scientists began a thorough investigatio of its properties. As a result of this investigation, IBM ha evolved new techniques to improve some of its most im portant characteristics. A stage of development has bee reached where germanium Esaki Diodes can be made wit peak-to-valley ratios averaging between 14 and 15 to and with peak currents that can be controlled within 1%

Looking at All Aspects

At IBM, the Esaki Diode is being examined from man viewpoints. Physicists and mathematicians are studyin the theoretical foundations of its behavior. Other scien tists and engineers are probing its electrical characteris tics. Still others are refining techniques for its constructio

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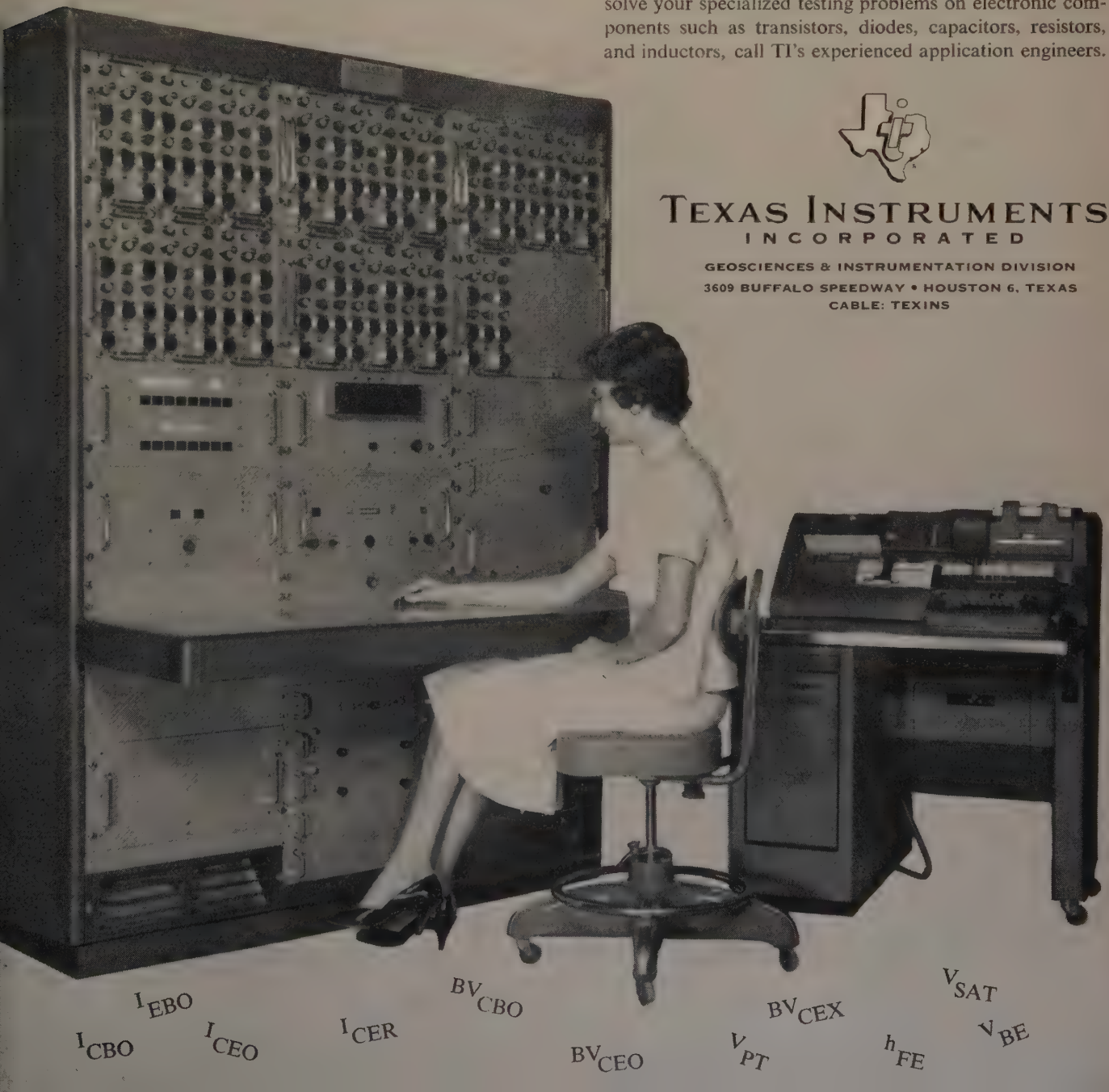

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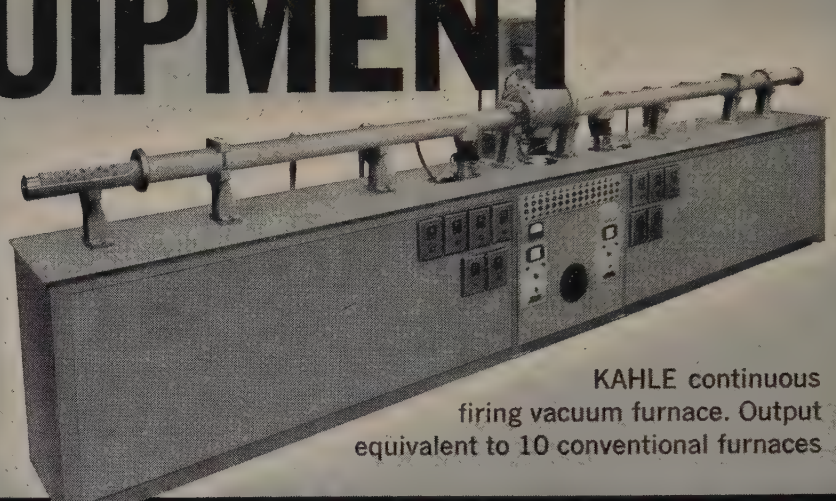

KAHLE continuous firing vacuum furnace. Output equivalent to 10 conventional furnaces

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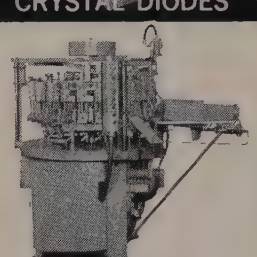
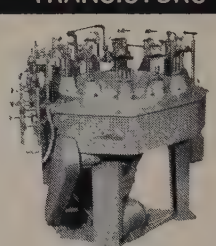


Crystal Diode Final Seal Machine No. 3117

TRANSISTORS



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Editorial . . .

Infrared Detectors

One of the most dramatic aspects of contemporary efforts in electronic technology is represented by the work at the upper limit of the frequency spectrum. Both the generation and the detection of infrared and of optical frequencies are of interest. However, while the generation of coherent oscillations, being attempted with masers, is still in its infancy, the detection of infrared and optical frequencies has made great progress in the past decade since the advent of the semiconductor era.

Photosensitive detectors of the thallium sulfide type were discovered back in 1917, but they were developed only during the last war. Thermal detectors and photodetectors are used. The first are based on absorption of the radiation by the lattice, which is thereby heated and produces a change in the electrical properties. The second types are based on direct absorption of the radiation by the electronic system, that is, liberation of hole-electron pairs and consequent production of electrical signals. The latter types are most promising, because their signals may be amplified to the limit permitted by the signal-to-noise ratio.

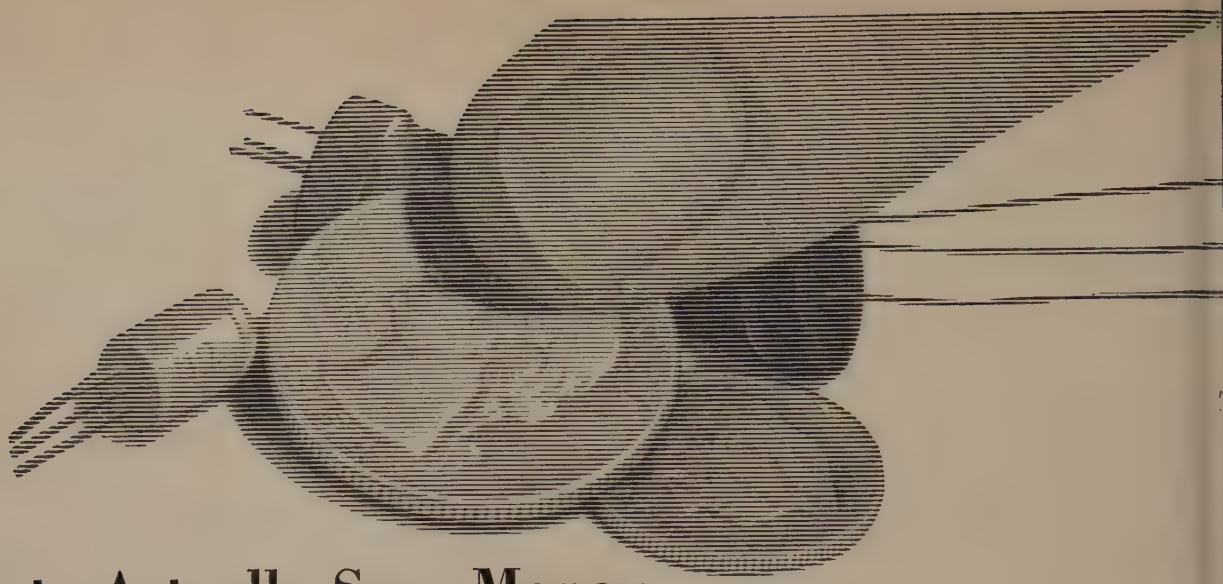
Photodetectors are classified as photoconductive, photovoltaic, and photoelectromagnetic. The photoconductive detectors utilize changes in the electrical conductivity of the semiconductor, produced by irradiation. Photovoltaic detectors utilize the open circuit voltage produced across a *p-n* junction by injection of photons in the junction. Photoelectromagnetic detectors utilize the interaction between holes and electrons, and an externally applied magnetic field, with the consequent production of a Hall-type voltage. Representative types of the photoconductors are thallous sulfide and lead sulfide devices, while representative types of photovoltaic and photoelectromagnetic devices are indium antimonide and tellurium devices. The spectral responses of these devices extends up to 4 or 5 microns; in intrinsic semiconductors this limit depends upon the energy gap and is expressed by the relation $\lambda_{max} = hc/E_g$.

The sensitivity of photodetectors depends on the energy gap, impurity content, absorption coefficient, lifetime of carriers, etc. It is desirable that the energy gap be as small as possible and that the absorption coefficient and the lifetime be as large as possible. In modern detectors the absorption coefficient α has been increased from 10^{-1}/cm (germanium) to 10^{4}/cm (InSb); since the penetration of the radiation into the semiconductor is measured by $1/\alpha$, it is seen that the required thickness of the device has been decreased from 10 cm to 1 micron. Similarly the lifetime has been increased from values of the order of microseconds to values of the order of milliseconds.

The performance of infrared detectors is limited by noise; this is caused by background radiation, by lattice generation and recombination of carriers, by Johnson noise, and by $1/f$ noise. In an ideal detector only the background noise should be predominant, a condition which is approximated by appropriate cooling. Some photodetectors require cooling to the temperature of liquid nitrogen, but it is anticipated that in the near future satisfactory operation may be obtained at room temperature.

The importance of the infrared detectors in applications is obvious. In industry they permit the identification of many chemical and biological phenomena by non-destructive means. In the military art they supply a resolution which is much higher than that available with present radars, and furthermore are of passive type. Many future applications are foreseen in navigation, astronomy, instrument landing, altimeter and telemeter determination, missile guidance, secure communications, detection, etc.

Samuel L. Marshall



How to Actually Save Money While Improving Your Transistors

Ultra-Pure Graphite parts give longer service . . .

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Transistorized Automobile Receivers Employing Drift Transistors

RICHARD A. SANTILLI* C. FRANK WHEATLEY*

This article describes six all-transistor automobile radios designed to use a five-stage lineup including *rf* amplier, converter, *if* amplifier, first-audio, and power-output stages. The six receivers differ in having three-coil or four-coil tuners and Class A or Class B output. All six variations have a sensitivity of approximately two microvolts antenna signal for one watt of audio power. Sensitivity for a 20-*db* signal-to-noise ratio is five to ten microvolts (depending upon circuit). The Class A output circuit delivers about four watts of undistorted power and the Class B output circuit about eight watts of undistorted power. The receivers "overload" at about one volt on the antenna.

THIS ARTICLE DESCRIBES various five-stage transistor automobile receivers designed to use commercial drift transistors in the *rf*, converter, and *if* stages. These drift transistors, which inherently have a high maximum available gain and low feedback capacitance, provide good performance with a minimum number of stages and thus contribute to low over-all circuit cost.

The transistor lineup for the basic receiver is as follows: a 2N640 *rf* amplifier, a 2N642 converter, a 2N641 *if* amplifier, a 2N591 audio driver, and either a single-ended or push-pull audio-output stage using 2N301's. The receiver has an antenna sensitivity of two microvolts for one watt of audio output. The single-ended audio circuit is capable of delivering an audio output of four watts at a distortion of less than ten per cent, and a maximum output of seven watts. The push-pull audio circuit is capable of delivering an audio output of eight watts at a distortion of less than ten per cent, and a maximum output of fourteen watts. Various front-end designs for the basic five-stage receiver are described, and the relative merits and characteristics of each are discussed.

Antenna Circuitry

The whip antenna used for automobile receivers may be represented by a voltage generator with a capacitive internal impedance. Although a resistive component of impedance is also present, its value is so low that it may safely be neglected over the broadcast band when a 6-to-8-foot whip antenna is used. Analysis shows that when the loaded Q is fixed for bandwidth purposes, maximum power transfer is obtained when (a) the unloaded Q is as high as possible, (b) trimmer and other shunt capacitors are kept to a minimum, and (c) padders and other series capacitors are kept to a maximum.

A 6-to-8-foot whip antenna for the broadcast band can be represented by a voltage generator in series with a 30 micromicrofarad capacitor. The lead-in cable introduces shunt capacitance of the order of 30 micromicrofarads for front-mounted antennas and 120 micromicrofarads when the antenna is mounted at the rear of the car. Because the majority of applications employ front-mounted antennas, the antenna coils were designed for a 30 micromicrofarad series, 30 micromicrofarad shunt dummy antenna. A 100 micromicrofarad fixed padder can be added to the antenna coil to accommodate a rear-mounted antenna, but the added shunt capacitance of the rear-mount lead-in cable and the loss in the 100 micromicrofarad series trimmer result in a loss in sensitivity. Although an input coil tuned by a large capacitance could have been designed to accommodate both antennas, the result would be inferior performance for the front-mounted antenna. If only one antenna coil design is to be used for both applications, the padder approach is recommended.

There are many ways of coupling the antenna coil to the base of the 2N640 *rf* amplifier transistor. Most of the more practical methods are shown in *Fig. 1*. The choice of one of these coupling circuits depends upon the over-all receiver objectives with regard to crosstalk, 60-cycle rejection, cost, and insertion loss.

Crosstalk is the modulation of a desired signal by an undesired signal at the base of the *rf* amplifier.

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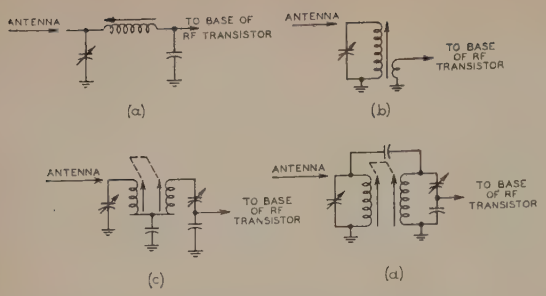


Fig. 1—Practical antenna coupling circuits for auto receiver.

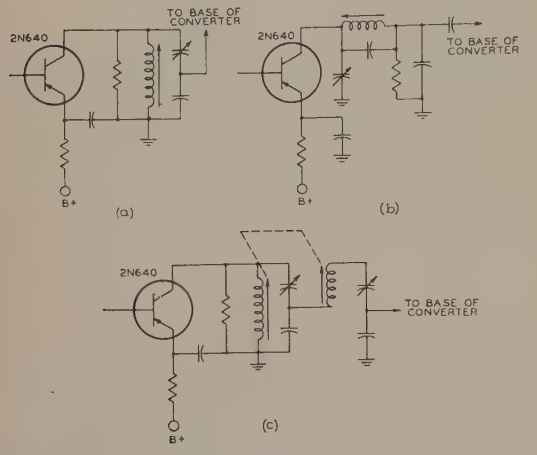


Fig. 2—Practical *rf* coupling circuits for receiver.

When an off-resonance signal is present, it appears attenuated at the transistor base. The strength of the undesired signal and the front-end selectivity determine the magnitude of the undesired signal at the *rf* amplifier base. If the signal level is significant, *rf* distortion occurs and produces crossmodulation or crosstalk. The coupling circuits shown in *Figs. 1 (c)* and *1 (d)* have considerably better crosstalk characteristics than the circuits shown in *Figs. 1 (a)* and *1 (b)*. (The difference becomes quite pronounced when the undesired signal is very strong.)

In actual use, an automobile receiver encounters 60 cycle radiation of the order of volts from transmission lines or neon signs. If the rejection of the coupling circuit to 60 cycles is not sufficient, serious modulation at the base of the *rf* transistor will result. Good 60 cycle rejection is provided by the circuits of *Figs. 1 (b)* and *1 (d)*.

Finally, for a good signal-to-noise ratio, the insertion loss must be kept to a minimum. Although the double-tuned antenna has an obvious disadvantage with respect to insertion loss, the loss can be minimized by over-coupling. About 25 or 30 per cent of over-coupling can be used without sweep generator alignment being required.

R.F.-Amplifier Stage

One of the most significant requirements for the 2N640 *rf* amplifier transistor is the automatic-gain-control (*agc*) requirement. (The control of *rf* input and output impedances and feedback capacitance is an obvious requirement.) Because the range of signal levels encountered in an auto radio covers approximately 110 to 120 *db*, the *rf* transistor must provide 80 to 90 *db* of *agc*. As a result, its *dc* beta (common-emitter current transfer ratio) and I_{CBO} (cutoff collector current) must be controlled so that the *agc* system can supply sufficient power to utilize this cutoff range without separate *agc* amplification. This requirement becomes even more significant at higher ambient temperatures. The 2N640 drift transistor is designed specifically to meet these stringent requirements.

Under no-signal conditions, the *rf* stage is operated at a collector voltage of —12 volts and a collector current of 0.7 milliampere, and produces a power gain of 27 *db* at the low-frequency end and 20 *db* at the high-frequency end of the band. This gain is adequate to over-ride the converter noise, but is still sufficiently below the maximum capabilities of the 2N640 to assure excellent interchangeability and stability.

Three practical circuits for coupling the *rf* power into the base of the 2N642 converter transistor are shown in *Fig. 2*. In three-coil tuners, the circuits shown in *Figs. 2 (a)* and *2 (b)* are the only practical choices (excluding a double-tuned antenna and broadband *rf* load). The only significant performance differences between these circuits concern *if* and image rejection. The circuit of *Fig. 2 (a)* has good image and *if* rejection. The circuit of *Fig. 2 (b)* splits the *rf* tuning capacitor to form a tunable (not tracked) image trap which provides superior image rejection at some sacrifice in *if* rejection. Because image rejection is normally a more severe problem than *if* rejection with a 262.5 kilocycle *if*, the circuit of *Fig. 2 (b)* is the more practical one to use. For this circuit, the best image-rejection performance across the band is obtained when the trap is tuned to approximately 1725 kilocycles (for a signal frequency of 1200 kilocycles.)

In four-coil tuner applications, any of the circuits shown in *Fig. 2* may be used. If a single-tuned antenna is used because of signal-to-noise considerations, however, the double-tuned circuit of *Fig. 2 (c)* is the only choice.

Converter Stage

The converter circuit shown in *Fig. 3* is basically the autodyne type, in which emitter injection is obtained by capacitive division. This circuit uses a 2N642 drift transistor which is specifically developed and controlled for optimum converter performance. The *rf* signal is fed into the base, as mentioned previously. The *if* output from the collector is fed through a double-tuned transformer to the base of the *if* amplifier transistor. The converter transistor operates at a collector voltage of —12 volts and a

ollector current of 0.6 milliampere, and produces a onversion gain of 37 *db* (for a 262 kilocycle *if*). gain, this gain is below the maximum capabilities f the 2N642 and assures excellent interchangeability nd stability.

The conversion gain of this stage is relatively inependent of base-to-emitter oscillator injection voltge over the range of 50 to 150 millivolts. Outside this ange, the conversion gain decreases. The converter xhibits an increase in injection voltage with dereasing frequency. This variation was employed to ecrease the conversion gain at the low end of the and to compensate for the increase in gain of the *rf* mplifier. Additional compensation is provided by the mitter resistor, which is not as well bypassed for lowrequency *rf* signals as for high-frequency signals.

Oscillator Blocking

The major problem in the design of the converter tage was that of blocking. When a very high level *rf* ignal is applied to the base of the converter transisor, the stage operates as a clamping circuit, thereby everse-biasing the transistor and preventing oscillaion. Without oscillation, there is no *if* output and, herefore, no *agc* to reduce the high level *rf* input. If he incoming signal increases gradually, the *agc* has a chance to build up. However, the full signal may be applied abruptly if push-button tuning is used or if he receiver is turned on in the presence of a strong signal. Although a suitable bypass capacitor could be incorporated so that the *rf* stage would gradually obtain bias (i.e., a "turn-on transient" could be built into the circuit), this arrangement is no solution for push-button blocking, or for blocking caused by tuning to a strong station.

The best method of eliminating blocking is to determine empirically the maximum *rf* signal the converter can accept without blocking, and then limit the signal below this level. The collector of the *rf* transistor will limit to a certain level, depending on collector load and *d-c* biases. If the coupling to the converter base then has a sufficient step-down, blocking is eliminated.

I.F.-Amplifier Stage

A 2N641 drift transistor is used in the unneutralized 262 kilocycle *if* amplifier, as shown in *Fig. 4*. Double-tuned input and output transformers with coefficients of coupling set at 0.85 critical are used to obtain the desired selectivity. Although more gain could be obtained with a higher collector load, and even more with neutralization, the *if* stage must deliver a high level of power. Consequently, the collector load is determined by large-signal Class A power amplifier criteria rather than by considerations of dynamic stability alone. For a collector voltage of —12 volts and a current of 2 milliamperes, a collector load of 6000 ohms is used. The *if* amplifier stage contributes 32 *db* of gain.

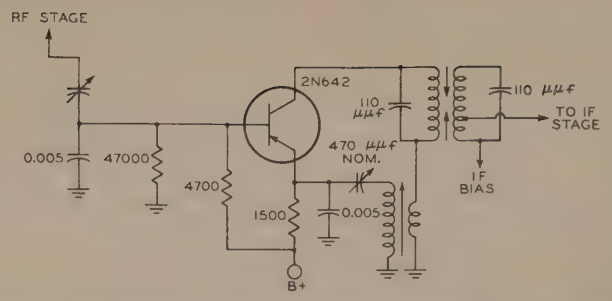


Fig. 3—Autodyne type converter circuit using 2N642.

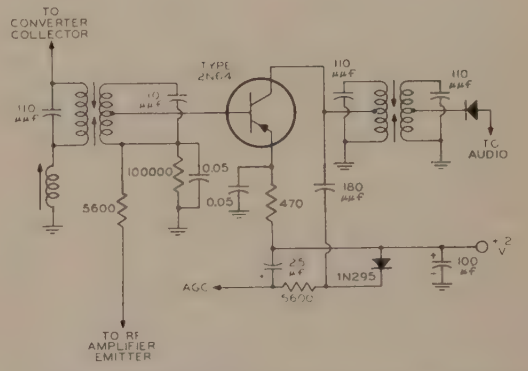


Fig. 4—Unneutralized 262 kilocycle *if* amplifier stage using 2N641.

The audio detector is fed from a tap on the secondary winding of the *if* output transformer. The *agc* detector is fed by a capacitor from the collector of the *if* transistor. This arrangement provides a slightly wider bandwidth for the *agc* than for the audio, and also permits a high level of *agc* voltage.

Approximately 6 to 8 *db* of *agc* is obtained from the *if* stage. The *agc* bias is obtained from the *rf* transistor emitter.

Automatic Gain Control

The 110 to 120 *db* signal handling requirement of this receiver makes automatic gain control a difficult problem. The *agc* detector develops approximately 2 volts. A tendency toward distortion at very high signal levels was corrected by the use of a 2 micromicrofarad capacitor between the base and the collector of the *rf* transistor. This capacitor apparently extends the *agc* to some extent by introducing a feedthrough current which subtracts from the normal collector signal current. These currents are normally out of phase.

Another problem encountered in the *agc* system was that of spurious responses at very high levels. When a strong signal is present and the receiver is tuned "on carrier," reception is normal. As the receiver is tuned "off carrier," however, the *agc* voltage decreases rapidly. The *if* transistor collector signal (and the resultant *agc* voltage) decreases more rapidly with detuning than the signal at the *rf* transistor base because of the difference between over-all

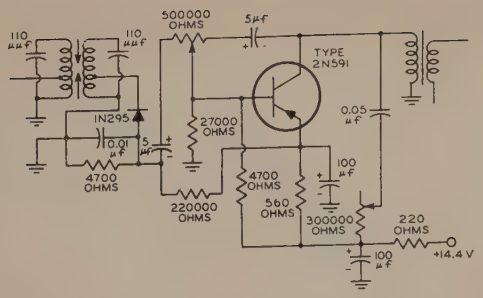


Fig. 5—Audio driver stage using 1N295 detector and 2N591 driver transistor.

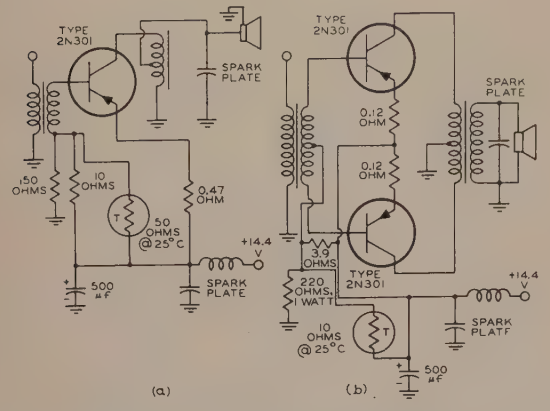


Fig. 6—(a) Four-watt single-ended audio output circuit. (b) Eight-watt push-pull audio output circuit.

selectivity and antenna selectivity. In the absence of *agc*, a very strong *rf* signal overloads the *rf* stage, causing many harmonics and resulting in spurious responses.

Audio Detection

A 1N295 point-contact germanium diode is used as the audio detector, as shown in *Fig. 5*. For detection of small signals, maximum sensitivity is obtained by passage of a certain value of forward *d-c* current through the diode. As the current is reduced from this value, a slight loss in sensitivity is encountered. For signals 5 or 10 *db* lower, however, a considerable loss of sensitivity is observed. A high degree of quieting in the absence of a signal can be obtained with only a slight reduction in normal sensitivity by utilization of this nonlinearity of the detector. Although this arrangement does not actually improve the signal-to-noise ratio at sensitivity, it provides a subjective advantage similar to noise limiting. The compromise detector bias employed in this receiver causes a sharp curvature in the *agc* curve at sensitivity level. Admittedly, this curvature introduces detector distortion, as will be discussed later.

Because the *if* amplifier stability and bandwidth are functions of the double-tuned output circuit, variations due to detector loading should be kept to a minimum. If the *d-c* bias current in the diode is zero, the characteristics of a conventional peak detector are present (i.e., the load at zero signal is quite high and decreases rapidly to a constant value *R*, with increasing signal). For large *d-c* bias currents, the characteristics of a square-law detector are present (i.e., the load at small signal levels is very low). When the detector is heavily driven, peak detection is restored and the same constant load *R*, results. For intermediate *d-c* biases, the detector load is relatively independent of signal level and is equal to *R*.

Maximum sensitivity is obtained when most of the load on the detector is provided by the input impedance of the audio transistor (i.e., when the *d-c* load is small compared to the *a-c* load). However, a high degree of distortion is introduced by this arrangement, particularly at high modulation levels.

For operation at high sensitivity, the noise is sufficiently high to override the distortion. A signal-to-noise ratio of 20 *db* contributes as much undesired power as a distortion of 10 per cent. Distortion means little, therefore, at signal-to-noise ratios below 20 to 25 *db*.

When the signal level is high enough to obtain a signal-to-noise ratio of 20 to 25 *db* (about 5 to 8 microvolts), the detector is fairly linear. In addition, either the output is clipped rather badly, or the user turns down the volume control. The first 10 to 20 *db* of volume reduction inserts series resistance between the detector and transistor, thereby unloading the detector to approach an *a-c* to *d-c* ratio of unity.

Audio Driver

The 2N591 germanium-alloy audio driver transistor is specially designed for the high-temperature and high-voltage requirements of this application. The driver operates at a collector-to-emitter voltage of −12 volts and a collector current of 3 milliamperes, and provides a power gain of approximately 44 *db*.

Volume Control

The volume control is a high-resistance potentiometer connected between the audio detector and the collector of the driver transistor. When the variable arm (connected to the base of the driver transistor) is placed at the detector end of the potentiometer, maximum sensitivity is obtained. The resistance of the potentiometer is high enough so that no appreciable collector-to-base feedback is encountered. As the arm is moved away from the detector closer to the transistor collector, series attenuation is introduced and unloads the audio detector. Additional reduction of volume causes collector-to-base feedback, which not only reduces the driver distortion (if significant), but also lowers the output impedance of the driver. Further decrease of the volume-control setting results in additional feedback and, finally, attenuation produced by loading of the driver collector. Volume adjustment of about 100 *db* can be obtained by this method. For best results, the volume control should have an "S" taper with about 5 per cent of total resistance at 35 per cent rotation and 95 per cent of total resistance at 65 per cent rotation.

When the output stage is driven by a current source, the presence of an unbypassed emitter resistor is not degenerative. Consequently, there is no loss of sensitivity (although a greater dynamic range is required). When the output impedance of the driver is reduced by the feedback of the volume control, however, an output-stage emitter resistor provides a significant amount of loop feedback.

Tone Control

A treble-cut tone control circuit is incorporated between the collector of the driver transistor and ground. The capacitor in this circuit is chosen so that the 3-db-down frequency for full cut is about 400 cycles at high volume settings.

Audio Output

Two audio output circuits were considered for the receiver: a four watt single-ended circuit, and an eight watt push-pull circuit. The audio output stage for the four watt circuit consists of a single 2N301 germanium power transistor operated under Class A conditions, as shown in *Fig. 6 (a)*. When this transistor is driven without regard to distortion, the power-output level is seven watts.

An autotransformer is used for the output transformer to obtain the best performance (relative to frequency response and efficiency) for a given volume of iron. Although this arrangement places a *d-c* bias on the speaker and results in cone displacement, the speaker distortion can be kept small if the bias is kept to approximately 100 millivolts. Consequently, the *d-c* resistance of the common winding should be quite small (in this application, less than 0.15 ohm).

The audio-output stage for the eight watt circuit consists of a pair of matched 2N301 germanium power transistors operated under Class B conditions, as shown in *Fig. 6 (b)*. When this circuit is driven without regard to distortion, the power-output level is 14 watts.

In either circuit, the power transistor(s) must be provided with an adequate heat sink so that the maximum junction temperature will not exceed 85 degrees centigrade.

Receiver Performance

Fig. 7 shows the circuit diagram for the basic five transistor receiver. The *rf* amplifier stage uses a three-coil tuner (single-tuned antenna, *pi* load). The converter, *if* amplifier, and driver stages are the same as described earlier except that a capacitor having a negative temperature coefficient is used to shunt the converter tuning capacitor to provide oscillator frequency stability with temperature. The audio output circuit is the four watt circuit described previously.

In the converter circuit shown in *Fig. 7*, the oscillator *"tickler"* winding of the converter stage is located below the first *if* transformer. If the tickler winding is located between the collector of the 2N642 and the *if* transformer winding, the capacitance of the tickler winding to ground shunts the *if* transformer primary and changes the coefficient of coupling. When this arrangement is used, the shunting capacitance must be considered in the design of the *if* transformer.

Fig. 8 shows four practical *rf* amplifier circuits which may be used in this receiver. All measurements referred to in the remainder of this article were made with a 30 micromicrofarad series, 30 micromicrofarad shunt dummy antenna, and with the 100 micromicrofarad padder shorted. The measured sensitivity over the broadcast band in all cases was found to be 2 microvolts ± 2 *db* for 30 per cent, 400-cycle modulation. Sensitivity is measured at 1 watt of audio output for both the four watt and the eight watt circuits.

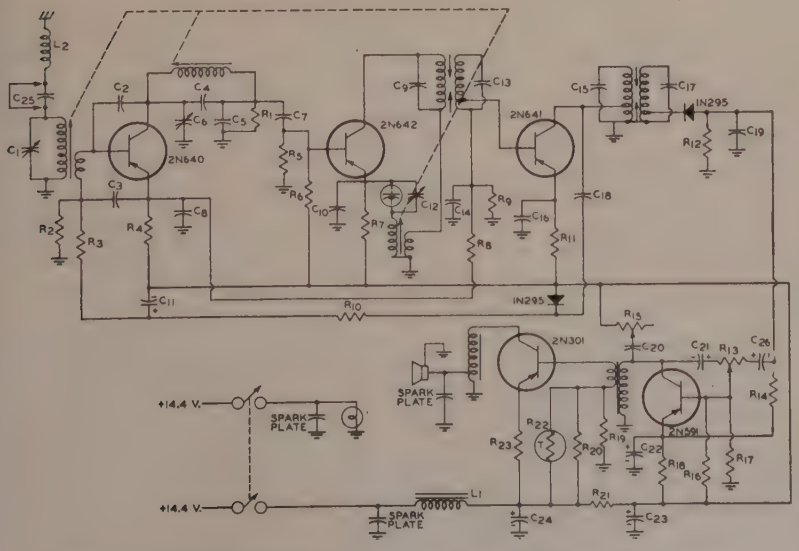


Fig. 7—Circuit diagram for basic five transistor receiver.

PARTS LIST

C_1—50 mmf	R_1—180 ohms
C_2—2 mmf	R_2—150K
C_3 C_7 C_8 C_{14} C_{16} C_{20}—0.05 mf	R_3—2200 ohms
C_4—390 mmf	R_4 R_{15}—560 ohms
C_5—0.0082 mf	R_5—47K
C_6 C_{13} C_{15} C_{17}—110 mmf	R_6 R_{12} R_{16}—4700 ohms
C_9—590 mmf	R_7—1500 ohms
C_{10}—0.005 mf	R_8 R_{10}—5600 ohms
C_{11}—25 mf, electrolytic	R_9—100K
C_{12}—470 mmf	R_{11}—470 ohms
C_{18}—180 mmf	R_{13}—potentiometer, 500K
C_{19}—0.01 mf	R_{14}—220K
C_{21} C_{26}—5 mf, electrolytic	R_{15}—potentiometer, 300K
C_{22} C_{23}—100 mf, electrolytic	R_{17}—27K
C_{24}—500 mf, electrolytic	R_{19}—150 ohms
C_{25}—100 mmf (open shorting bar for rear-mounted antenna)	R_{20}—10 ohms
	R_{21}—220 ohms
	R_{22}—thermistor, 50 ohms at 25°C
L_1—filter choke	R_{23}—0.47 ohm
L_2—5 μh	

NOTE: For class B circuit, change R_2 to 100K and R_4 to 1K.

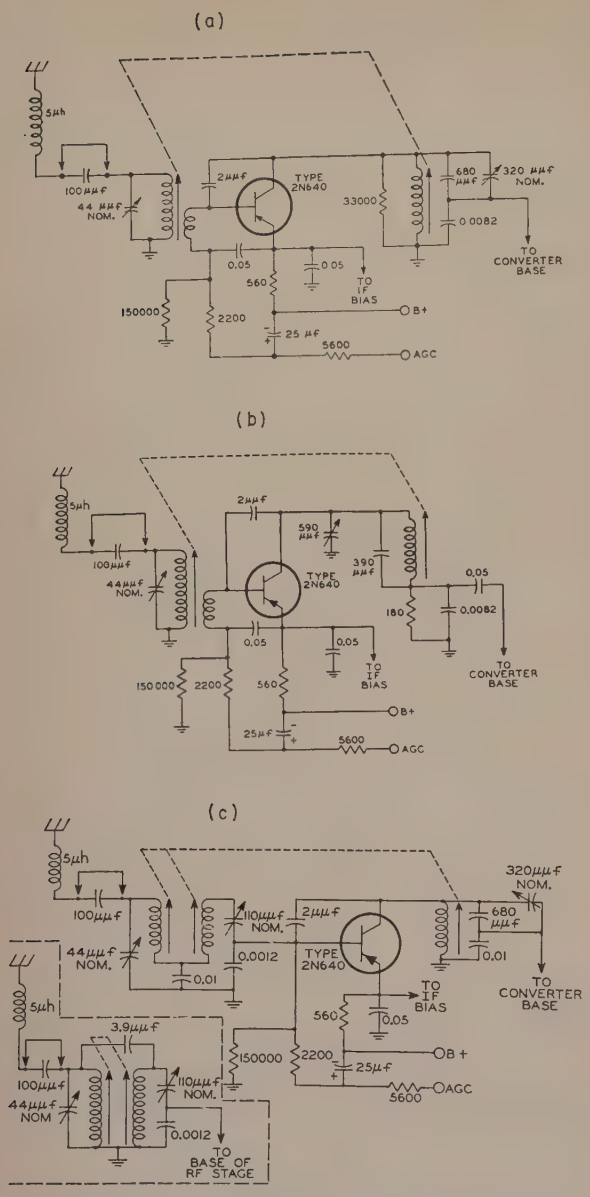


Fig. 8—Practical *rf* amplifier circuits for receiver.

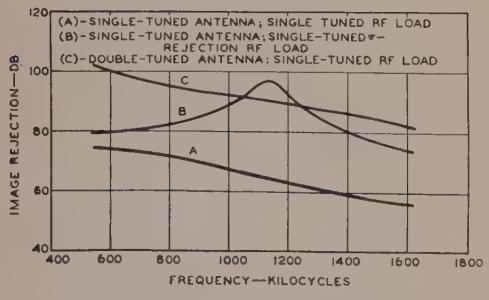


Fig. 9—Image rejection characteristics of *rf* amplifier circuits shown in Fig. 8.

The *if* rejection for all four *rf* amplifier circuits exceeded 75 *db* across the band. The image rejection characteristics for the various circuits are shown in *Fig. 9*. Curves A, B, and C show the image rejection

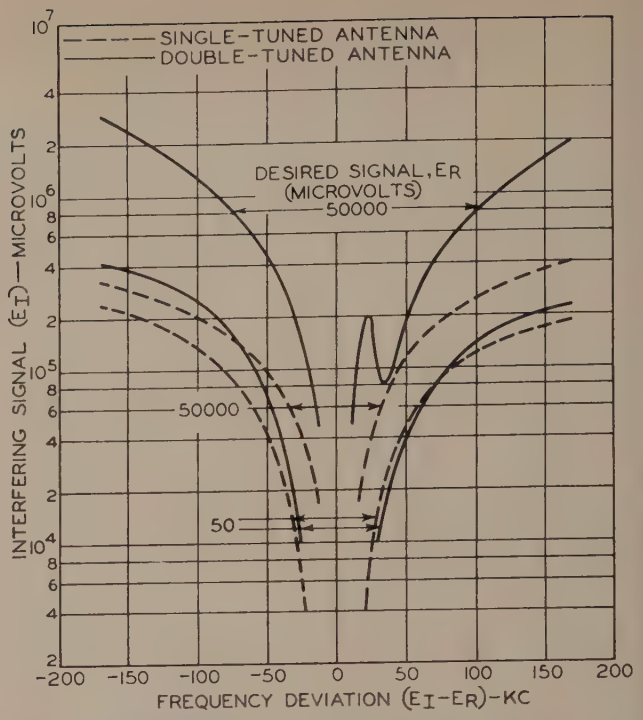


Fig. 10—Crosstalk characteristics for single-tuned and double-tuned antenna coupling circuits.

characteristics of the circuits in *Figs. 8(a)*, *8(b)*, and *8(c)*, respectively. It can be seen that the image-rejection characteristic for the circuit shown in *Fig. 8(b)* resonates at 1200 kilocycles, as discussed previously. The circuit shown in *Fig. 8(c)* could also use a *pi* filter as an *rf* load if additional image rejection were required.

Fig. 10 shows the crosstalk characteristics for the single-tuned and double-tuned antenna-coupling circuits. With the receiver tuned to E_r (one megacycle, 30 per cent, 400 cycle modulation), the volume control was adjusted to obtain one watt of audio output. Fig. 10 shows the interfering signal level E_i, (30 per cent, 1000 cycle modulation), necessary to produce one milliwatt of 1000 cycle audio output. This signal level is plotted as a function of frequency deviation from the receiver signal, E_r, for values of E_r equal to 50 microvolts and 50,000 microvolts.

It can be seen that there is no major performance difference for interfering signals up to 100,000 microvolts. Beyond this value, however, the double-tuned antenna is superior; in fact, if signal levels in excess of 0.25 volt are anticipated, the double-tuned antenna must be employed.

The antenna-coupling circuits shown in *Fig. 8* were also evaluated for rejection of a 60 cycle field. The inductively coupled circuits of *Figs. 8(a)* and *8(b)* exhibited a rejection in excess of 170 *db*. The bottom-side-coupled circuit of *Fig. 8(c)* exhibited a rejection of approximately 105 *db*, and the top-side-coupled circuit of greater than 250 *db*. The 60 cycle rejection of *Fig. 8(c)* may be increased approximately 40 *db* by use of a 2700 ohm resistor in parallel with the

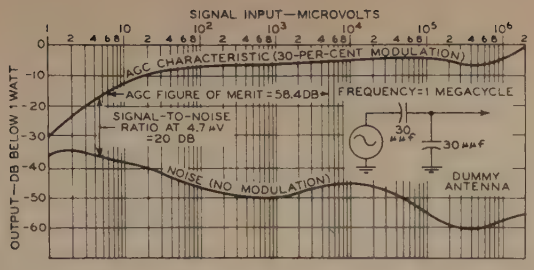


Fig. 11—*AGC* and noise characteristics of receiver shown in Fig. 7.

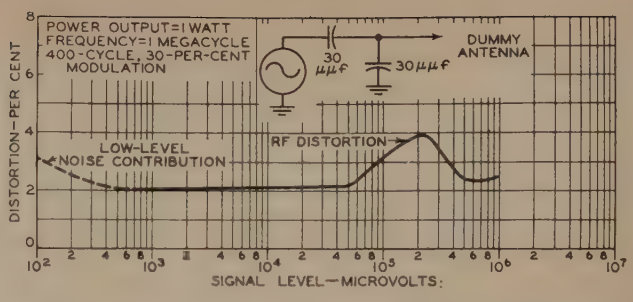


Fig. 13—Distortion as a function of *rf* signal level.

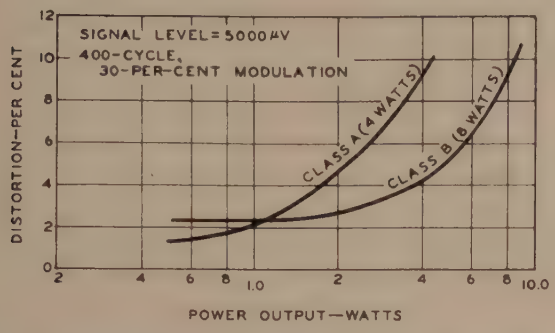


Fig. 12—Distortion as a function of power output for audio-output circuits shown in Fig. 6.

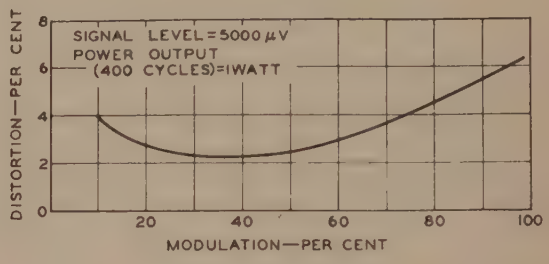


Fig. 14—Distortion as a function of per-cent modulation.

coupling capacitor. This resistor will not affect the circuit in any other manner.

Fig. 11 shows the *agc* and noise characteristics of the basic receiver shown in *Fig. 7*. For the double tuned antenna coupling circuits, the signal-to-noise performance near sensitivity is reduced by 4 *db*. In addition, when the eight watt audio-output circuit is used, the *agc* must be delayed to insure that it does not limit the available audio signal.

Fig. 12 shows distortion as a function of power output for the two audio-output circuits described previously. *Fig. 13* shows distortion as a function of *rf* signal level for an audio output of 1 watt.

Fig. 14 shows distortion as a function of per cent modulation for an audio output of 1 watt at an *rf* signal level of 5000 microvolts.

Conclusion

This article has described many of the considerations involved when drift transistors are used in an automobile receiver. Excellent reliability, instant response when turned on, and low current drain are just a few of the advantages realized with an all-transistor automobile receiver. With the techniques described, a receiver can be built for six-volt or twelve-volt, positive-ground or negative-ground operation. This design results in a truly universal receiver.

Correction

The article, 'A Review of Parametric Diode Research,' by G. C. Messenger, which appeared on pages 17-19 of the January 1960 issue of SEMICONDUCTOR PRODUCTS, referenced Mr. Messenger's association with Hughes Aircraft Company, Hughes Semiconductors, Newport Beach, California. The article was, however, prepared by Mr. Messenger while he was employed by Philco Corporation and with minor exception deals with developments of Philco Corporation. In the published article, *Figure 4*, reflecting packaging concepts which are a development of Hughes Aircraft Company, was substituted for *Figure 4* of the original Philco paper which showed a Philco diode. This and certain other editorial changes were made by Mr. Messenger subsequent to the termination of his employment at Philco Corporation.

Esaki or Tunnel Diodes

WOLFGANG W. GÄRTNER*

Part 2

This survey article discusses the physical effects which produce the electrical characteristics of the tunnel diode, outlines design and construction of the devices, describes the electrical properties realized thus far, gives diagrams and design equations for *d-c* bias, oscillator, amplifier and switching circuits, and analyzes in general the potentialities of the new device.

Negative-resistance Amplifiers

The two-terminal amplifier usually presents certain conceptual difficulties to the tube and transistor engineer since it provides for no separation of input and output. This second property of "directionality," if desired, must be realized separately from the negative-resistance element, by means of a "gyrator"[14] and one arrives at the concept of the "dissected amplifier."[15] This is a perfectly feasible procedure in the microwave region where low-loss circulators are available. At lower frequencies, a convenient gyrator has not yet been realized. We are concerned here only with the amplification provided by the negative-resistance element. *Fig. 12* shows the basic amplifier circuit. We define power gain, A_P, as the ratio $A_P = P_o/P_L$ where P_o is the output power delivered into G_L with the amplifier (diode and L) connected, $P_o = |v^2|G_L$ and P_L is the power delivered from the generator into G_L when the amplifier is not connected:

$$P_L = | v_g^2 | G_g^2 G_L/(G_g + G_L)^2 \qquad (20)$$

Similarly, we may define the transducer gain, A_T, as a ratio; $A_T = P_o/P_{av}$ where $P_{av} = |v^2_g|G_g/4$ is the available power from the generator.

With reference to *Fig. 12*, we find, assuming $r \simeq 0$,

$$| v^2 | = | v_g^2 | \frac{G_g^2}{\gamma^2 + \Omega^2} \qquad (21)$$

where

$$\gamma = G_g + G_L - G,$$
$$\Omega = (\omega_0^2 - \omega^2)C/\omega,$$
$$\omega_o = 1/\sqrt{CL}.$$

We thus obtain for the power gain as a function of frequency,

$$A_P = (G_g + G_L)^2/(\gamma^2 + \Omega^2) \qquad (22)$$

and similarly for the transducer gain,

$$A_T = 4G_gG_L/(\gamma^2 + \Omega^2) \qquad (23)$$

The center of the amplifier band lies evidently at $\omega = \omega_0$ where the power and transducer gain reach their maximum values:

$$A_P(\omega_0) = (G_g + G_L)^2/\gamma^2 \qquad (24)$$

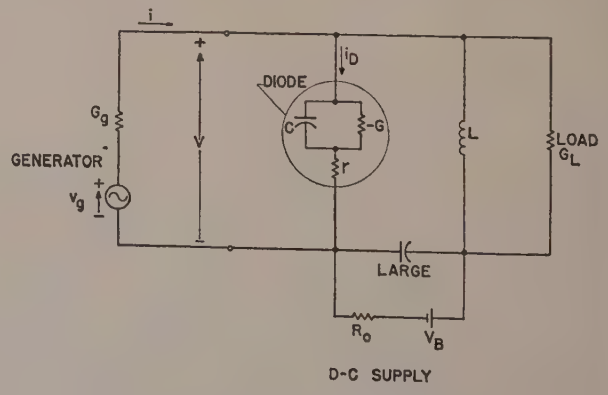
and

$$A_T(\omega_o) = 4G_gG_L/\gamma^2 \qquad (25)$$

For $\gamma = 0$, i.e., $G_g + G_L = G$, the gain becomes infinite and the circuit begins to oscillate. For stable amplifier operation, the condition

$$G_g + G_L > G \qquad (26)$$

must, therefore, always be satisfied. This is sometimes achieved by impedance transformation of the generator and load conductances. Stable transducer gain of approximately 20 *db* up to frequencies of 100 *mc* has been obtained experimentally. Since the value of G may vary considerably with temperature (see *Fig. 6*), it may be necessary to provide for temperature stabilization of the amplifier gain, e.g. by controlled variation of the operating point using thermistors. To determine the 3 *db* bandwidth, B, we find the frequencies, ω', where power and transducer gains are



$$i = v\left[G_L + 1/(j\omega L) + Y/(1 + rY)\right], \quad Y = -G + j\omega C$$

$$i = (v_g - v)G_g$$

Fig. 12—Basic negative-resistance amplifier circuit.

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down to one half their mid-band values, i.e., where $\gamma^2 = \Omega^2$, which leads to

$$B = 2 \mid \omega' - \omega_0 \mid /(2\pi) = (\omega_0/\pi) \{[\gamma^2/(4\omega_0^2 C^2) + 1]^{\frac{1}{2}} + \gamma/(2\omega_0 C) - 1\}. \quad (27)$$

The bandwidth evidently approaches zero as $\gamma \to 0$, i.e. $(G_g + G_L) \to G$, which simultaneously leads to infinite power gain and instability. For small γ we have

$$B \simeq \gamma/(2\pi C). \quad (28)$$

A gain-bandwidth product may be defined as $B\sqrt{A_T}$ which may serve as a figure of merit for the diode and the circuit. It reaches a maximum value of

$$(B\sqrt{A_T})_{max} = G/(2\pi C) = 1/(2\pi RC) \quad (29)$$

for $\gamma \to 0$ and $G_g = G_L \simeq G/2$ (but still $G_g + G_L > G$) The importance of small R and C in the diode is thus again emphasized.

By using maximally-flat filter circuits instead of single-tuned circuits[16,17] the bandwidth may be increased considerably (up to approximately 75%).

The advantages and disadvantages of the inherent small voltage swing of the device which have been pointed out in connection with the oscillator circuits above appear in similar form in the amplifier. The *d-c* power consumption of a very small signal tunnel-diode amplifier in particular is considerably less than that of a transistor amplifier with the same power gain.

Amplifier Noise Figure[18]

The noise figure, F, of an amplifier is defined as the ratio of the total output noise power (into G_L), P_{no}, to the noise output power due to the thermal noise in the generator, P_{nLg}, equal to the available thermal noise power from the generator,

$$P_{n,av} = v_{ng}^2 G_g/4 = kT_g \Delta f \quad (30)$$

times the transducer gain of the amplifier, given by Eq. 25. T_g is the temperature of the generator conductance. The total output noise power is calculated with the aid of *Fig. 13*. It consists of three contributions:

$$P_{no} = P_{nLg} + P_{nLd} + P_{nLL} \quad (31)$$

where P_{nLg} is the output noise power due to the thermal noise from the generator:

$$P_{nLg} = 4kT_g(G_g G_L/\gamma^2)\Delta f; \quad (32)$$

P_{nLd} is the output noise power due to the shot noise in the diode:

$$P_{nLd} = 2qI_o\,(G_L/\gamma^2)\,\Delta f; \quad (33)$$

P_{nLL} is the output noise power due to the thermal noise of the load conductance, G_L:

$$P_{nLL} = 4kT_L(G_L^2/\gamma^2)\,\Delta f, \quad (34)$$

where T_L is the temperature of the load conductance, G_L.

We thus find for the noise figure, F:

$$F = \frac{P_{no}}{P_{nLg}} = 1 + \frac{T_L}{T_g}\frac{G_L}{G_g} + \frac{qI_0}{2kT_g}\frac{1}{G_g} \quad (35)$$

For a small noise figure, it is therefore advantageous to make the load conductance much smaller than the generator conductance; to have the load conductance at a low temperature; to have a small *d-c* current through the diode; and to make the generator conductance as high as possible. For high gain, it is necessary that G_g be not much bigger than G (see Eq. 25) so that we find the following lower limit on the noise figure of a tunnel diode amplifier* (T_g assumed equal to room temperature, 300°K).

$$F > 1 + 20I_0/G \quad (36)$$

A low-noise amplifier, therefore, requires a diode with a high negative conductance at low *d-c* current levels. Unfortunately, the temperature dependence of G is most severe near the current minimum at the valley point.

Chang[19] reports noise figures between 4.5 and 6.3 *db* for amplifiers which at 30 *mc* give 20 to 40 *db* transducer gain with a bandwidth of approximately .2 *mc*.

In addition to the basic noise sources mentioned above, another noise mechanism with a $1/f$ spectrum is active at lower frequencies[20] which is believed to be connected with crystal imperfections and with the excess current mentioned earlier.

Switching Operation[21]

Bi-stable pulse circuits are one of the most promising applications for tunnel diodes. Such circuits are much less sensitive to small changes in diode properties (for instance with temperature) or terminations than

*This formula has been derived by M. Schuller at the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J.

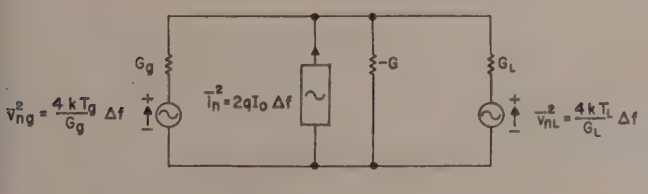

Fig. 13—Noise equivalent circuit of tunnel-diode amplifier.

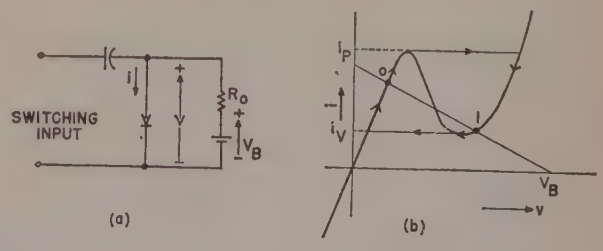

Fig. 14—Operation of the tunnel diode as a switch.

the small-signal amplifier circuits. Since the two-terminal device does not provide for separation of input and output, however, it requires major changes in the design of pulse systems. To operate the negative-resistance diode as a switch (see *Fig. 14*) the bias resistor, R_o, must be chosen such that the supply load line intersects the diode characteristic in two points, "0" and "1". The bi-stable circuit may then be found in either of these two states, "0" corresponding to low voltage and high current, and "1" corresponding to high voltage and low current. If the circuit is in state "0" and a pulse is applied which raises the current above the peak-current value, i_P, the instantaneous operating point (i, v) switches to "1" along the path approximately indicated by the arrows. For details see reference no. 12. It stays at "1" until another pulse reduces the current through the diode below the valley-current value, i_V, at which point the circuit switches back to "0" along the path indicated. The switching times, i.e., the duration of the transients, is limited by the frequency response of the diode, and switching times of 1 μsec have been achieved. The low voltage swing of the diode makes for an efficient switch with low *d-c* power consumption, but the output voltage is low and the circuit is more vulnerable to spurious pulses than, e.g., a conventional transistor multivibrator.

Arrays of tunnel diodes have been suggested as fast computer memories.[22]

Various other proposed circuits for the tunnel diode have been reported in the August 1959 issues of *Electronic Design, Electronic Industries* and *Electronic Equipment Engineering* as well as in the Feb. 3 and 17, 1960 issues of *Electronic Design.*

6. Conclusions

From the work which has been done thus far, there can be no doubt that the tunnel diode is highly promising as a simple high-frequency, low-noise active semiconductor element for switching, frequency conversion, oscillation and amplification (in this order), which is very insensitive to adverse environmental conditions. Its limitations lie in its high capacitance, low voltage swing, strong tendency towards unwanted oscillations and the fact that input and output are identical.

Future developments will bring integrated-circuit components which employ combinations of several tunnel diodes, and novel devices which contain junctions in which tunneling takes place and which interact with other semiconductor regions. As such, the tunnel diode may become an important link in microminiaturization and molecular electronics.[23]

Acknowledgement

It is a pleasure to acknowledge many interesting discussions on the subject with Mr. M. Schuller of the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey.

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Temperature Control of Silicon Solar Cells in Space Environment

WERNER LUFT* HARRY NASH**

The performance of silicon cells in converting radiant energy into electrical energy is dependent on the cell temperature. Most affected by temperature is the optimum power transfer characteristic, which has a temperature coefficient of —0.6% per degree centigrade. In a space environment the temperature of a solar collector is determined by the radiation equilibrium and hence by the optical characteristics of its surface. Conventional silicon solar cells have optical characteristics which produce higher surface temperatures than desired for good operating efficiency. Optical coatings have been developed which notably reduce the temperature, with corresponding increase in power output.

THE AVAILABILITY OF SILICON SOLAR CELLS with high conversion efficiencies has made practical the utilization of solar energy for space power supplies. The cells are, essentially, the semiconductor *p-n* junction devices invented at the Bell Telephone laboratories.[1, 2] They have now been developed into module assemblies offering high efficiency (of the order of 10%), low weight, good thermal characteristics and rugged contact construction.[3] The use of these silicon solar cells for space power systems is considered economical for power requirements up to several hundred watts.[4, 5] A primary consideration for silicon solar cell collectors in space is control of the cell temperature to achieve optimum power to weight ratio. Conventional non-coated silicon cells operate at higher temperatures than desired for good efficiency. By optical coating of the surface of these cells, the temperature can be reduced and the efficiency improved. The following discussion is centered about the temperature influence on the electrical characteristics of solar cells, and the determination of cell temperature in space. Data is also presented on the effect of optical coatings on the surface temperature and spectral response of the silicon cell.

Temperature Influence on Electrical Characteristics

The electrical characteristics of silicon solar cells are dependent upon the cell temperature. Of major interest for solar cell power supply design is the performance at optimum power transfer, which exists when the cells are operated into a matched load resistance. The effect of temperature on these characteristics is illustrated in *Fig. 2*. It will be noted that the optimum power output decreases nearly linearly with increasing temperature over a wide range. The temperature coefficient in the temperature range —10°C to +170°C is approximately —0.6%/°C. The voltage at optimum power transfer has a temperature coefficient of —0.54%/°C in the same range.

To operate at optimum power transfer while the cell temperature is fluctuating would require a variable load resistance. However, solar collectors are mostly operated either into a fixed load resistance or

Fig. 1—Five cell shingled module. (International Rectifier Corp.)

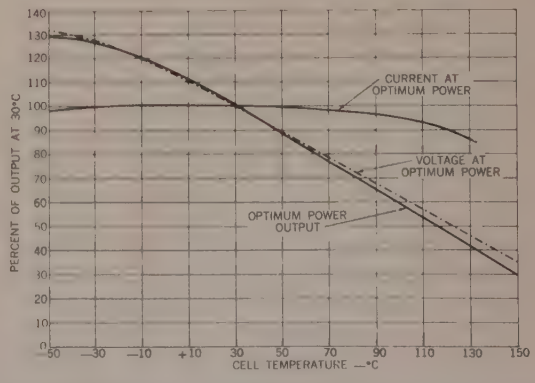
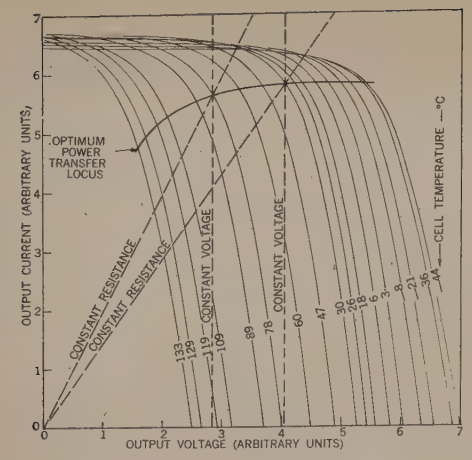
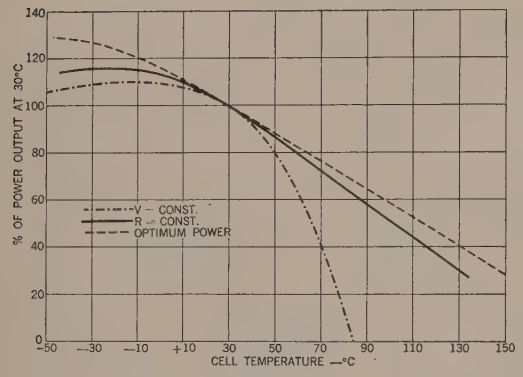


Fig. 2—Temperature variation of solar cell characteristics under optimum conditions.

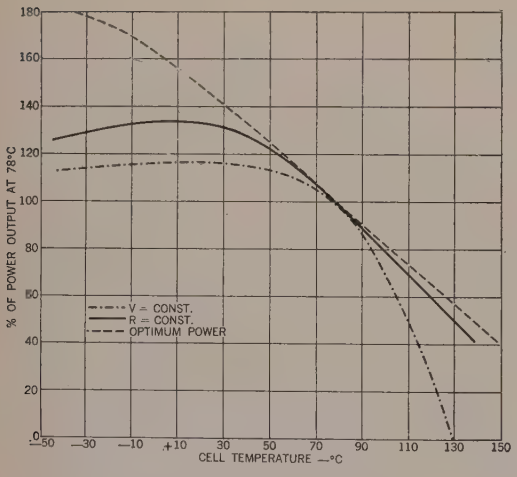
* International Rectifier Corporation of El Segundo, Calif.
** Formerly with International Rectifier Corp. Now with General Instrument Corp., Newark, N. J.



(a)



(b)



(c)

Fig. 3(a)—Variation of current voltage characteristics with temperature; (b) Power output at constant load and constant voltage compared with optimum power output vs cell temperature, for load and voltage giving optimum power output at 30°C.; (c) Same as 3b, but for load and voltage giving optimum power output at 78°C.

at nearly constant voltage, e.g., when charging batteries. In the first case, the output varies along the constant resistance line in *Fig. 3a* with varying temperature and in the second case along the constant voltage line. From the figure it is clearly seen that in both cases the output will be less than under optimum conditions represented by the optimum power transfer locus, except at one temperature.

When designing a power supply to operate at varying solar cell temperature, one must, therefore, first establish at what temperature point optimum performance is desired. The magnitude of this output can be determined from *Fig. 2.* The deviation from this output at various temperatures must then be established. *Figs. 3b* and *3c* are examples of the change in output for two reference temperatures, viz., 30°C and 78°C respectively. Both the variation at constant load and constant voltage are illustrated. The power output at constant voltage decreases more rapidly with increasing temperature than at constant resistance. For reference, the change in optimum power transfer is also shown.

From this discussion it is evident that the solar cells should be operated at as low temperatures as feasible and that the temperature excursion from the temperature at which the load has been matched be kept as small as possible.

If not only the temperature but also the radiation intensity vary simultaneously the problem becomes more complex and must be solved for each case with help of curves similar to *Fig. 3a.*

Determination of Surface Temperature of Solar Collectors

The surface temperature of a solar collector of given configuration and direction with respect to the sun, situated in space, is determined by its spectral emissivity and internal energy generation or absorption. This temperature can be expressed in terms of the collector's surface characteristics, viz., the ratio of its average absorptivity for incoming radiation, $\bar{\alpha}$, to its average emissivity at equilibrium temperature, $\bar{\varepsilon}_T$, and the ratio of absorbing to emitting areas, A_a/A_ϵ. (See appendix and list of symbols, p. 43)

An example of the temperature dependence of the surface element ratios $\bar{\alpha}/\bar{\varepsilon}$ and A_a/A_ϵ is given in *Fig. 4.* The curves in the figure were calculated under the following assumptions:

1. $(\bar{\alpha}/\bar{\varepsilon})_T$ constant over total surface of element and independent of angle of incidence.
2. Unobstructed emission.
3. $C=1400\ W/m^2$ (Solar constant)
4. 10% of incident radiation converted to electrical energy and transmitted away from collector. $(f=0.1)$

It is seen from the figure that for a ratio of A_a/A_ϵ of 1/2, which corresponds to a flat oriented collector with re-radiation also from its back surface and negligible temperature drop from front to back surface, the ratio $(\bar{\alpha}/\bar{\varepsilon})_T$ should not be much larger than 1. Otherwise, the temperature will be too high for good cell efficiency.

The optical characteristics of interest for standard solar cells have been determined by spectral reflectance measurements. For wave lengths below 1.2μ the integrating sphere was used, and above 1.2μ,

measurements were made with the black body reflectometer.[6] *Fig. 5* shows the spectral emittance for such cells. From this data the average absorptivity of standard cells for isolation in space $\alpha_{m=0}$ has been determined to be 0.93. The average absorptivity is assumed to be independent of the cell temperature for the temperature range of interest.

The spectral emittance data were also used to determine the average emittance as function of the solar cell temperature and the result is shown in *Fig. 6*.

From the above data it can be calculated that for a flat oriented collector with reradiation also from the rear surface having a $\bar{\varepsilon}_T=0.92$ $A_\alpha/A_\epsilon=0.5$ the cell temperature would be 84°C. Such temperature is higher than desirable because the optimum power output is only 67.5% of that at 30°C.

Temperature Control

In order to reduce the cell temperature, the ratio of $(\bar{\alpha}/\bar{\varepsilon})_T$ must be decreased. This may be done in either of two ways, reducing $\bar{\alpha}$ or increasing $\bar{\varepsilon}$. The reduction in $\bar{\alpha}$, without penalty in decreased output from the cells, can be achieved by reflecting such parts of the solar spectrum which cannot be converted into electrical energy by silicon solar cells, i.e., radiation of wave length below 0.4 microns and between 1.1 and 3μ, which represents 9% and 23% respectively of the total solar radiation in space. The typical relative spectral response of silicon solar cells is depicted in *Fig. 7*.

At the present time work is being done to develop an optical coating which exhibits such reflective characteristics together with high absorption in the region of 0.4 to 1.1 microns.

Efforts to increase the average emissivity have so far been much more successful. Two methods have come into use: 1) cementing a thin optically coated cover glass to the cell surface or 2) depositing a coating directly on the cell. The improvement in the emissivity can be seen in *Figs. 5* and *6*. With the glass cover $\bar{\varepsilon}_T$ increases to nearly 0.9. For the collector discussed above, the temperature is reduced to 52°C by using the glass covers. This represents an increase in power output of 27%, taking into account the small transmission loss due to the glass. The spectral transmittance of the glass cover cemented to the cell is illustrated in *Fig. 8*. The average absorptivity $\alpha_{m=0}$ is 0.90 to 0.91, thus a small improvement over the uncovered cell.

The cover glass for a 1 x 2 cm solar cell weighs only 6.6 x 10^{-2} grams, and may be applied to the silicon cells in any type of assembly. When applied to the standard module shown in *Fig. 1*, the entire assembly weight is approximately 2.0 grams. In addition to its function of temperature control, the cover glass also provides protection of the cell surface against micrometeorite erosion in space. The effect of such erosion on the glass will reduce its transmittance, but this

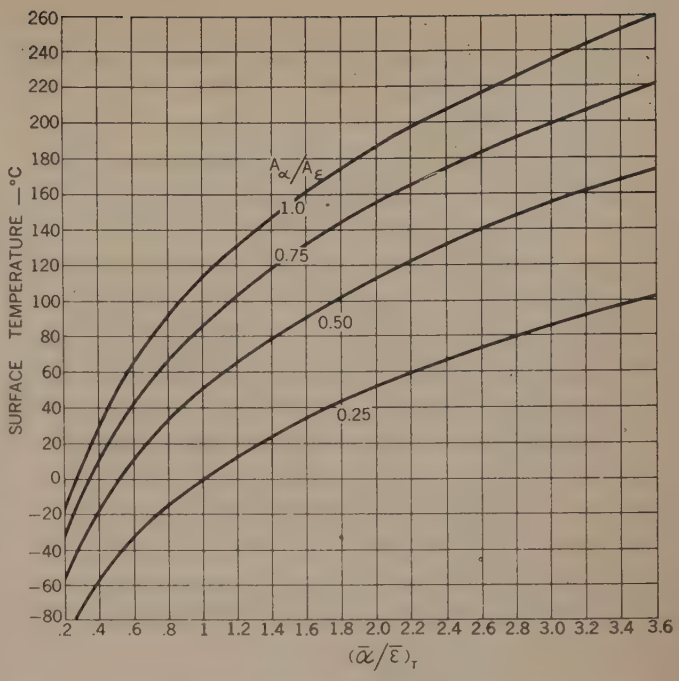


Fig. 4—Surface temperature of solar collector at $m = 0$ vs $(\bar{\alpha}/\bar{\varepsilon})_T$, with A_α/A_ϵ as parameter.

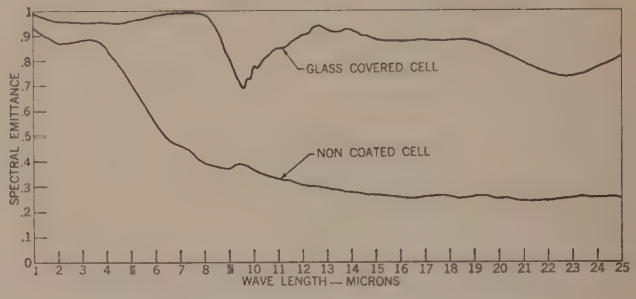

SPECTRAL EMITTANCE
GLASS COVERED CELL
NON COATED CELL
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
WAVE LENGTH — MICRONS

Fig. 5—Spectral emittance of solar cells.

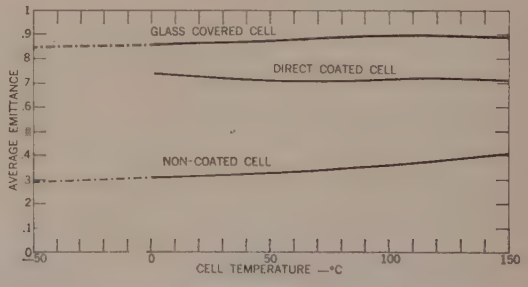


Fig. 6—Average emittance vs cell temperature.

may be taken into consideration by conservative design.

For direct coating of the solar cells, inorganic materials are vacuum deposited on the cell. The effect on the emittance is the same as with the glass, (see *Fig. 6*) but to a lesser degree. The thickness of the coating found most satisfactory is of the order of 10 μ. The increase in weight of a 1 x 2 cm solar cell by this coating is only 5 x 10^{-3} grams.

Of the two methods described for controlling the emittance, the cementing of cover glass to the cells

is contemplated for satellites presently in production. The evaporated direct coating is still in prototype development but shows great promise for future designs.

Spectral Distribution of Incident Radiation

As mentioned briefly above, the spectral response of solar cells varies with wave length (*Fig. 7*), the maximum response being at about 0.8μ. The efficiency of converting radiant energy into electrical energy will, therefore, be a function of the spectral distribution of the radiant energy.

The conversion efficiency of solar cells is normally specified for solar radiation at air mass one ($m=1$) and for matched load conditions. The spectral distribution of solar energy in space ($m=0$) is, however, quite different as seen from *Fig. 9*. Therefore, the conversion efficiency will be changed. How much the conversion efficiency will change can be determined from *Fig. 10*, which shows the relative spectral response of silicon cells for solar radiation at $m=0$ and $m=1$. The ratio of the integrals of these curves is 1.25 and is a measure of the expected change in output. The corresponding change in the magnitude of solar radiation is 1.5. Consequently, the efficiency of solar cells at $m=0$ is only 0.83 of its value at $m=1$

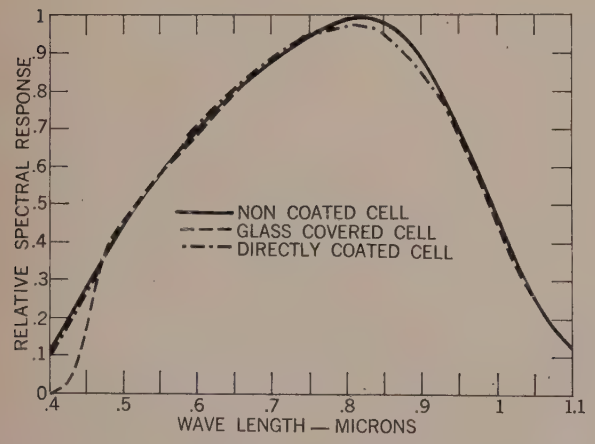


Fig. 7—Relative spectral response of short circuit current for radiation of constant power per unit wave length.

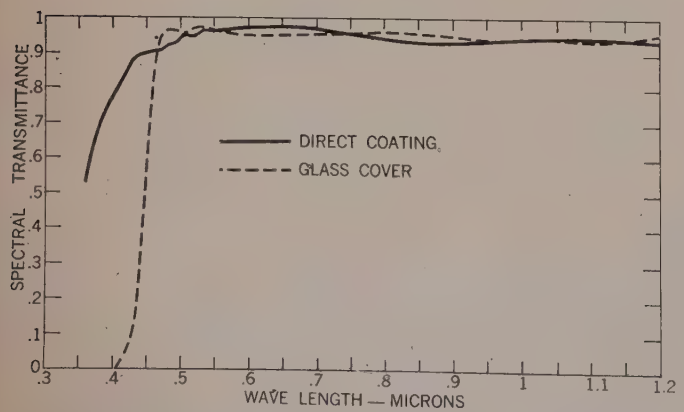


Fig. 8—Spectral transmittance of coating materials.

or $\eta_{m=0}=F_\lambda\eta_{m=1}$, where $F_\lambda=0.83$. This assumes a linear relationship between short circuit current and optimum power output, which holds approximately true for limited variation in magnitude of incident radiation. The spectral response for the glass covered cells is nearly the same as for non-covered cells (*Fig. 7*), therefore the same correction factor $F_\lambda=0.83$ can be used.

Conclusions

From the foregoing discussion it can be seen that the temperature of certain simple solar collector configurations in space can be determined without too great difficulty. For other collector configurations, such as non-oriented spherical collectors, the problems are much greater. In such cases the temperature and illumination intensity will vary over the collector surface, causing substantial matching losses. The treatment of these problems is, however, outside the scope of this article.

For solar collectors having uniform temperature and illumination intensity over their entire surface at any one time, the power output in space environment can be calculated from the spectral emittance characteristics of the collector surface and electrical data of the solar cell under normal conditions at the earth's surface. The influence of the spectral content of the incoming radiation on the conversion efficiency of solar cells must be considered. The reduction in conversion efficiency when going to space environment is a function of the spectral response of silicon solar cells and cannot be changed by external means. But the temperature of solar cells in space can be controlled within certain limits by optical coatings, with considerable improvement in power output.

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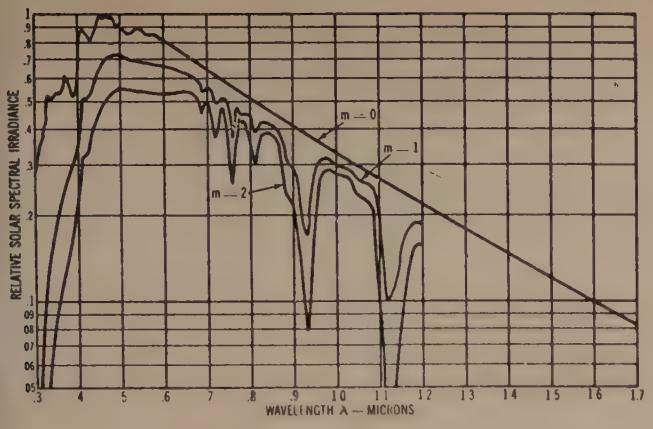
(7) F. S. Johnson, "The Solar Constant," *J. Meteorology, 2,* 431, (1954).

(8) P. Moon, "Proposed Standard Solar Radiation Curves for Engineering Use," *J. Franklin Inst., 230,* 583 (Nov. 1940).



$m = 0$ from F. S. Johnson "The Solar Constant," *Journal of Meteorology, Vol. II,* 1954, p. 431.
$m = 1$ and $m = 2$ from P. Moon "Proposed Standard Solar Radiation Curves for Engineering Use," *J. Franklin Inst., Vol. 230,* Nov. 1940, p. 583.
Pressure, 760 *mm* Hg; precipitable water, 20 *mm;* Dust; 300 particles per cm; Ozone, 2.8 *mm.*

Fig. 9—Relative solar spectral radiation.

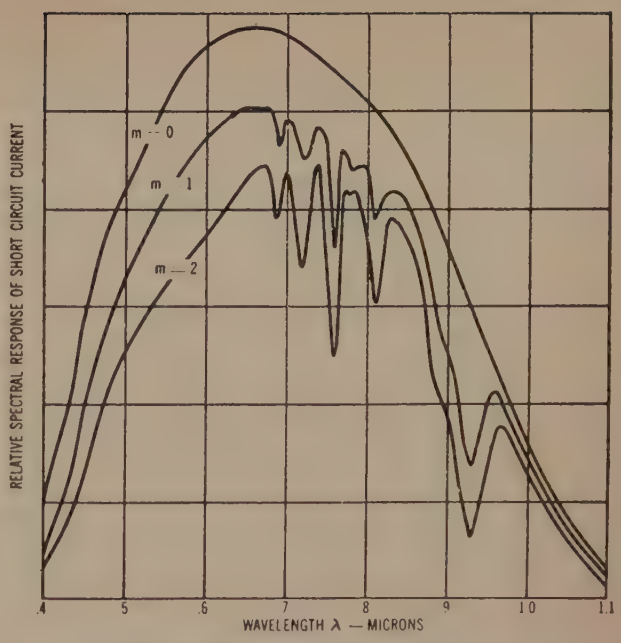


Fig. 10—Relative spectral response of short circuit current for solar radiation. (Non-coated cells.)

Symbols

A_α = Equivalent absorbing area m^2
A_ϵ = Emitting area m^2
T = Absolute temperature of surface °K
I_λ = Intensity of radiation per unit wave length increment at wave length λ. $w/m^2\ \mu$
I = Absorbed radiation. w/m^2
$W_{\lambda T}$ = Radiation power per unit area per unit wave length increment at wave length λ of black body at temperature T. $w/m^2\ \mu$
W = Total re-emitted power per unit area. w/m^2
$C = \int_0^\infty I_\lambda\, d\lambda \qquad w/m^2$
f = Fraction of I converted to electrical energy.
$\alpha_{\lambda T}$ = Spectral absorptivity of surface for radiation of wave length λ at surface temperature T.
$\epsilon_{\lambda T}$ = Spectral emissivity of surface for radiation of wave length λ at surface temperature T.
$\bar{\alpha}_T$ = Average absorptivity for radiation C of given spectral distribution of surface at temperature T.
$\bar{\epsilon}_T$ = Average emissivity of surface at temperature T.
σ = Stefan-Boltzmann's constant $(5.67 \times 10^{-8}\ wm^{-2} K^{-4})$.
m = Air mass.
F_T = Temperature correction factor for efficiency, relative to 30°C.
F_λ = Spectral correction factor for efficiency, relative to $m = 1$.
η = Conversion efficiency.
λ = Wave length.

Appendix

Temperature of surface element for heat transfer by radiation only.

Absorbed radiation $I = A_\alpha \int_0^\infty (\alpha_T I)_\lambda\, d\lambda$ (1)

By definition:

$$\bar{\alpha}_T = \int_0^\infty (\alpha_T I)_\lambda\, d\lambda \Big/ \int_0^\infty I_\lambda\, d\lambda \qquad (2)$$

Therefore, from Equations (1) and (2)

$$I = A_\alpha\, \bar{\alpha}_T \int_0^\infty I_\lambda\, d\lambda \qquad (3)$$

Emitted radiation according to Stefan—Boltzmann's law:

$$W = A_\epsilon\, \sigma\, \bar{\epsilon}_T\, T^4 \qquad (4)$$

where by definition

$$\bar{\epsilon}_T = \int_0^\infty (\epsilon\, W)_{\lambda T}\, d\lambda \Big/ \int_0^\infty W_{\lambda T}\, d\lambda \qquad (5)$$

If a fraction f of I is converted to electrical energy and removed from the surface element the power balance requires that

$$(1 - f)\, I = W \qquad (6)$$

Substituting Equations 3 and 4 in Equation 6 and calling the integral $\int_0^\infty I_\lambda\, d\lambda = C$ gives:

$$T = \left[(1 - f)\, \frac{C}{\sigma}\, \frac{A_\alpha}{A_\epsilon} \left(\frac{\bar{\alpha}}{\bar{\epsilon}} \right)_T \right]^{1/4} \qquad (7)$$

Application of Transistors To Video Equipment

Part 2.

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*Television Research Section, NHK Technical Research Laboratory, Tokyo, Japan.

This is the second of a series of articles describing developments in the transistorization of television transmitting equipment in Japan. The portable camera-transmitter was described in the first installment. The sync-signal generator is described in this issue. The concluding article in the series will treat the image orthicon camera.

Sync-Signal Generator

This transistorized sync-signal generator produces all the synchronizing wave forms necessary for developing complete monochrome and NTSC color video signals. The five wave forms, namely the horizontal and vertical driving pulses, blanking signals, composite sync-signal, color subcarrier and burst flag pulse, are all delivered in negative polarity at a level of 4*v*. peak-to-peak across a 75-ohm terminating resistance with the exception of the color subcarrier. This sync generator combines maximum flexibility of operation with high inherent stability in spite of its transistorized circuits.

Top and bottom photographs of the chassis are shown in *Fig. 11*. The equipment has a total power consumption of about 9 watts excluding the cooling fan, pilot lamp and relay. It may be operated from source voltages of either 24 *v. d-c* or 100—120 *v. a-c*, 50—60 *cps*.

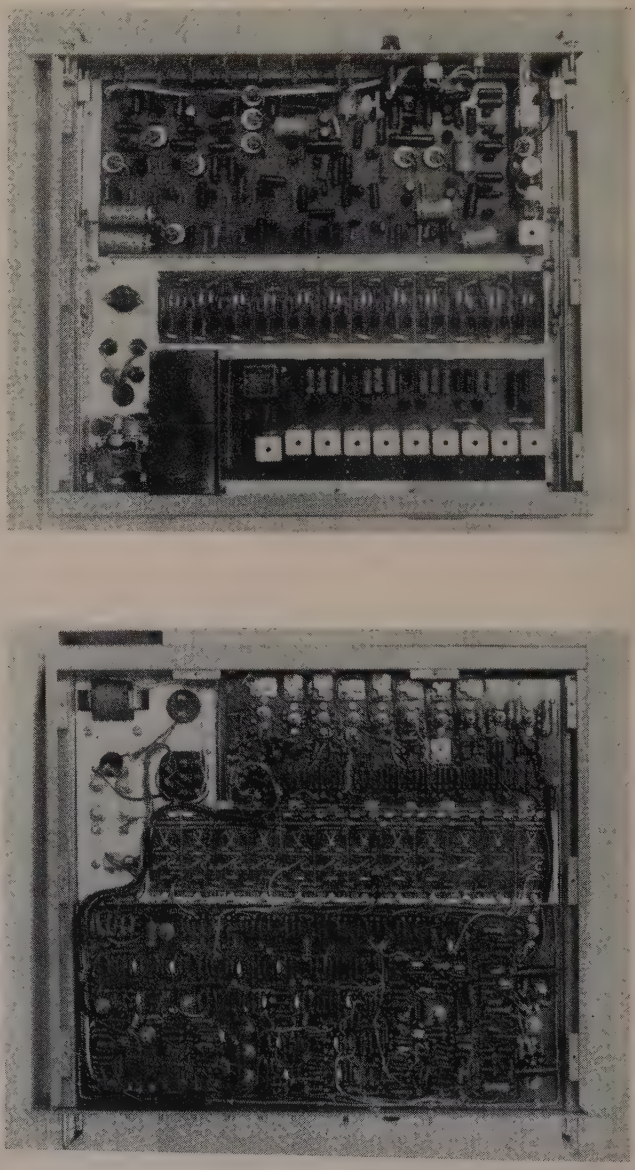

Fig. 11—Top and bottom views of sync signal generator.

Block Diagram

Fig. 12 shows a block diagram of the sync-signal generator. The circuits are divided into three main sections, namely, a counter, a pulse former and a color subcarrier generator. The counter, following the color subcarrier generator or monochrome 31.5 *kc* crystal oscillator, consists of ten flip-flop circuit modules and one gate. It makes use of ÷3, ÷7 and ÷25 feedback loops. These feedback loops are designed for generating the f_v gate pulses; that is 3H-3H (T), delayed 3H (S) and 9H (P).

The operating point of the flip-flop circuit has been improved by selecting it at a boundary between the active and the saturation regions of the dynamic operation characteristic for minimized over-shoot. This produces better count-down results, compared with former types. This circuit is called the "critical saturation flip-flop."

The pulse former produces the synchronizing, driving, and blanking waveforms which follow the gen-

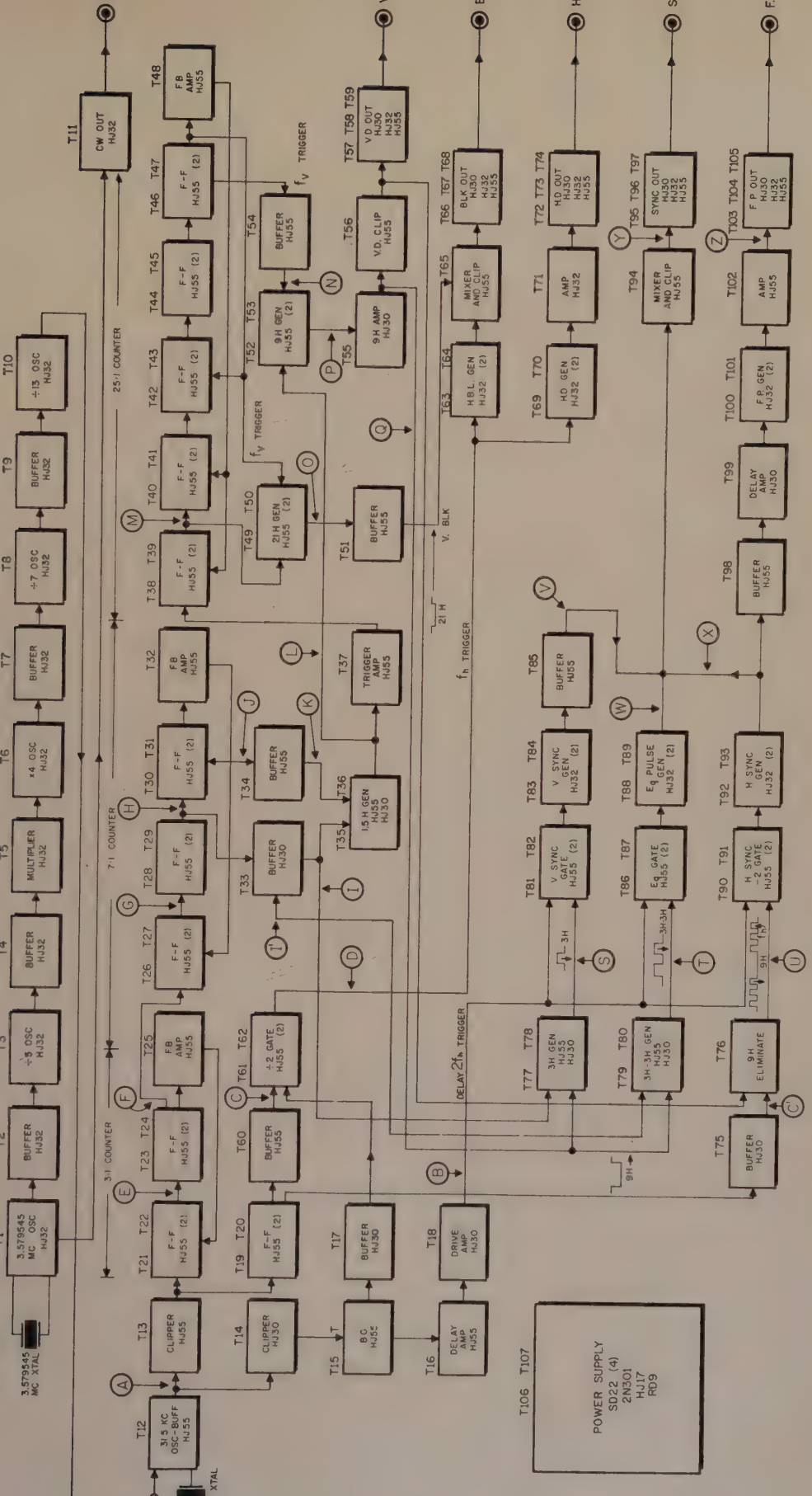
C.W.
V.D.
BLK
H.D.
SYNC
F.P.
T1 3.579545 MC OSC HJ32
T2 BUFFER HJ32
T3 ÷5 OSC HJ32
T4 BUFFER HJ32
T5 MULTIPLIER HJ32
T6 ×4 OSC HJ32
T7 BUFFER HJ32
T8 ÷7 OSC HJ32
T9 BUFFER HJ32
T10 ÷13 OSC HJ32
T11 CW OUT HJ32
T12 31.5 KC OSC-BUFF HJ55
T13 CLIPPER HJ55
T14 CLIPPER HJ30
T15 BC HJ55
T16 DELAY AMP HJ55
T17 BUFFER HJ30
T18 DRIVE AMP HJ30
T19 T20 F-F HJ55 (2)
T21 T22 F-F HJ55 (2)
T23 T24 F-F HJ55 (2)
T25 FB AMP HJ55
T26 T27 F-F HJ55 (2)
T28 T29 F-F HJ55 (2)
T30 T31 F-F HJ55 (2)
T32 FB AMP HJ55
T33 BUFFER HJ30
T34 BUFFER HJ55
T35 T36 15 H GEN HJ55 HJ30
T37 TRIGGER AMP HJ55
T38 T39 F-F HJ55 (2)
T40 T41 F-F HJ55 (2)
T42 T43 F-F HJ55 (2)
T44 T45 F-F HJ55 (2)
T46 T47 F-F HJ55 (2)
T48 FB AMP HJ55
T49 T50 21 H GEN HJ55 (2)
T51 BUFFER HJ55
T52 T53 9 H GEN HJ55 (2)
T54 BUFFER HJ55
T55 9 H AMP HJ30
T56 V.D. CLIP HJ55
T57 T58 T59 V.D. OUT HJ30 HJ32 HJ55
T61 T62 ÷2 GATE HJ55 (2)
T60 BUFFER HJ55
T63 T64 H.BL. GEN HJ32 (2)
T65 MIXER AND CLIP HJ55
T66 T67 T68 BLK OUT HJ30 HJ32 HJ55
T69 T70 H.D. GEN HJ32 (2)
T71 AMP HJ32
T72 T73 T74 H.D. OUT HJ30 HJ32 HJ55
T75 BUFFER HJ30
T76 9 H ELIMINATE
T77 T78 3 H GEN HJ55 HJ30
T79 T80 3H-3H GEN HJ55 HJ30
T81 T82 V SYNC GATE HJ55 (2)
T83 T84 V SYNC GEN HJ32 (2)
T85 BUFFER HJ55
T86 T87 Eq GATE HJ55 (2)
T88 T89 Eq PULSE GEN HJ32 (2)
T90 T91 H SYNC GATE HJ55 (2)
T92 T93 H SYNC GEN HJ32 (2)
T94 MIXER AND CLIP HJ55
T95 T96 T97 SYNC OUT HJ30 HJ32 HJ55
T98 BUFFER HJ55
T99 DELAY AMP HJ30
T100 T101 F.P. GEN HJ32 (2)
T102 AMP HJ55
T103 T104 T105 F.P. OUT HJ30 HJ32 HJ55
T106 T107 POWER SUPPLY SD22 (4) 2N301 HJ17 R09
3.579545 MC XTAL
31.5 KC XTAL
25:1 COUNTER
7:1 COUNTER
3:1 COUNTER
DELAY 2fh TRIGGER
fv TRIGGER
fh TRIGGER
V. BLK
21 H
3H
3H-3H
9H
fh

Fig. 12—Block diagram of transistorized sync signal generator.

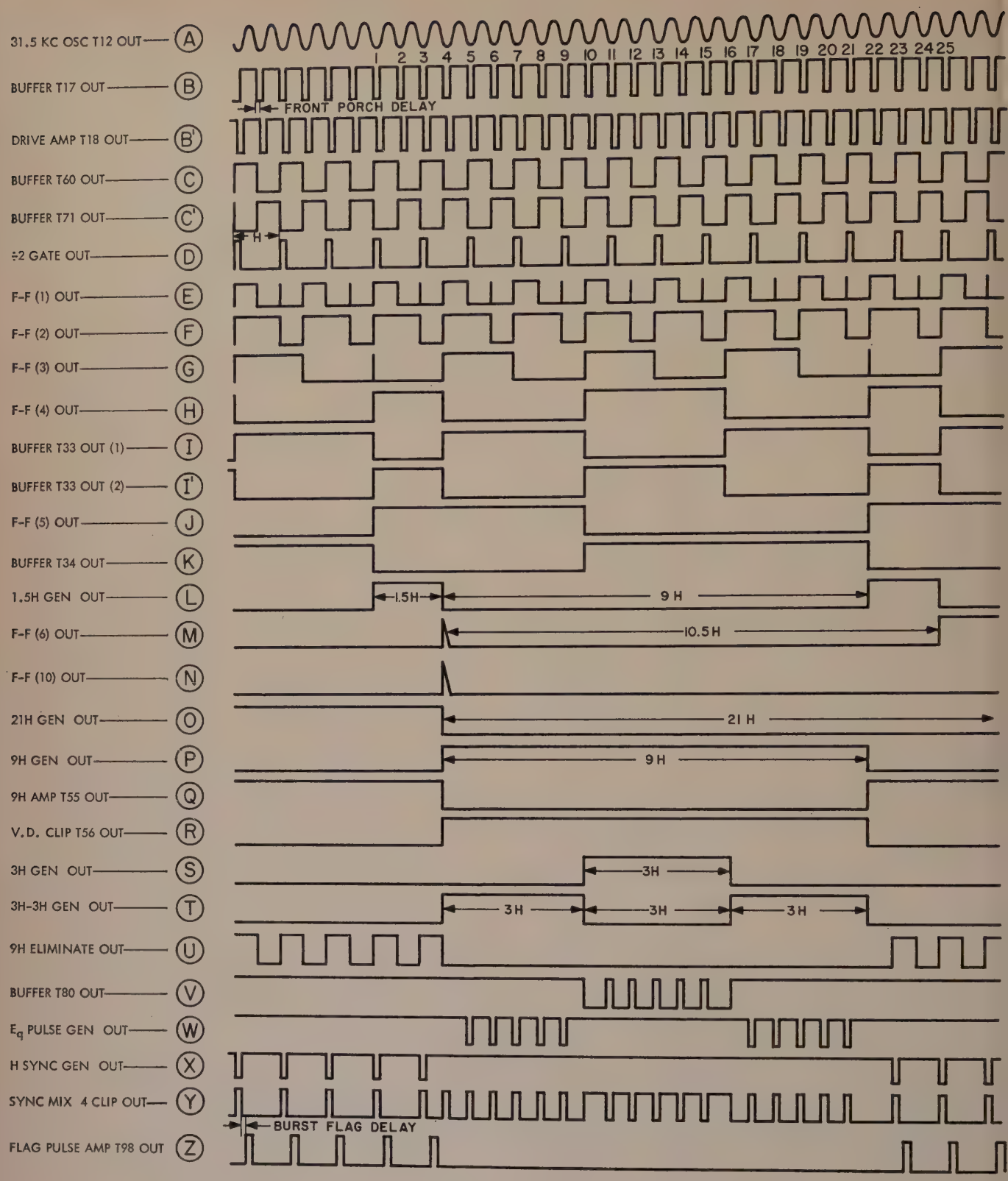
31.5 KC OSC T12 OUT — A
BUFFER T17 OUT — B
DRIVE AMP T18 OUT — B'
BUFFER T60 OUT — C
BUFFER T71 OUT — C'
÷2 GATE OUT — D
F-F (1) OUT — E
F-F (2) OUT — F
F-F (3) OUT — G
F-F (4) OUT — H
BUFFER T33 OUT (1) — I
BUFFER T33 OUT (2) — I'
F-F (5) OUT — J
BUFFER T34 OUT — K
1.5H GEN OUT — L
F-F (6) OUT — M
F-F (10) OUT — N
21H GEN OUT — O
9H GEN OUT — P
9H AMP T55 OUT — Q
V.D. CLIP T56 OUT — R
3H GEN OUT — S
3H-3H GEN OUT — T
9H ELIMINATE OUT — U
BUFFER T80 OUT — V
Eq PULSE GEN OUT — W
H SYNC GEN OUT — X
SYNC MIX 4 CLIP OUT — Y
FLAG PULSE AMP T98 OUT — Z
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
FRONT PORCH DELAY
1H
1.5H
9 H
10.5 H
21 H
9 H
3H
3H
3H
3H
BURST FLAG DELAY

Fig. 13—Chart of wave forms.

eral specifications of the EIA. Their rise and fall is within 0.2μs at the crossing wave-forms of 75 ohm line output.

Line Output Amplifier

The line output amplifier shown in *Fig. 14* can deliver the above mentioned pulses, because the transistors allow high peak currents exceeding the normal rating (in this case 10 *ma* for common high frequency alloy transistors) and the collector-grounded circuit has superior high frequency characteristics when driven by the voltage signal source.

Wave Forms

The wave forms of the pulse trains at various points in the circuit are shown in *Fig. 13.*

The f_v gate pulse is generated in the flip-flop and the gate circuit. The 9H pulse is formed at flip-flop *T52* and *T53* which is triggered with the f_v trigger pulse (*N*) and 1.5H -9H pulse (*L*). The output wave-form of counter 4 (*I*) is gated with the 9H pulse to form the 3H-3H pulse (T), provided for equalizing the pulse period.

The delayed 3H pulse (S) corresponding to vertical sync serration is similarly produced with the inverted wave-form of (I) and the 9H pulse. The f_h pulse sequence is generated in the monostable multivibrator and the gate circuit. For example, the composite sync signal is formed as follows. The equalizing pulses are formed in the monostable multivibrator *T88—T89* triggered by the delayed $2f_h$ timing pulse, which is gated at *T86—T87* during 3H-3H periods. The vertical sync pulses (V) are produced by a similar monostable multivibrator *T83—T84* in much the same manner as the equalizing pulses, after gating delayed 3H period at *T81—T82*. The delayed $2f_h$ timing pulse corresponding to the front porch is generated through the time delay circuit *T16* following the blocking oscillator *T15*. The horizontal sync (X) is produced similarly from monostable multivibrator *T92—T93* controlled by the f_h trigger, which is gated from $2f_h$ delayed pulse and suppressed during the 9H pulse period at *T90—T91*. These pulses, (V) (W) (X), are combined in 3 diode "OR" gates and then fed to the line output amplifier to produce a composite sync-signal (Y).

The leading edges of these 3 pulses should coincide with the same timing position, so that each pulse is

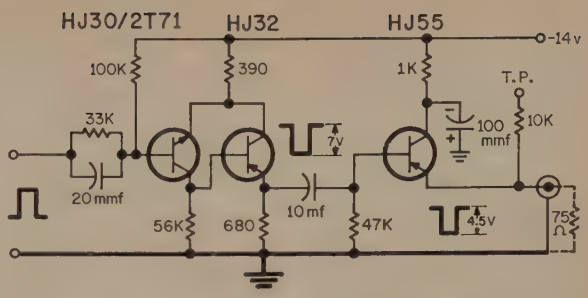

Fig. 14—Schematic of line amplifier.

formed through the same type gate and monostable multivibrator which is triggered by the single delayed $2f_h$ timing pulse source.

The crystal-controlled oscillator T1 which generates a *cw* of 3.579545 *Mc* is held to within ±10% against temperature drift between 10°C and 50°C. The frequency stabilized Hartley oscillator, *T3*, functioning as a locked oscillator, divides the input frequency by five. Similar circuits which employ base injection of the high frequency signal are used in the other multiplying and dividing networks (x 4, ÷7, ÷13) and maintain a frequency relationship of 4/455. Test points exist between each dividing section and supervise the count-ratio.

The circuit design of the sync signal generator provides stable operation with a variation of ±15% in line voltage and an ambient temperature range of 10°C to 50°C.

This transistorized sync signal generator satisfies the requirements of monochrome and NTSC color television standards, and suggests the future of sync signal generator models.

[To be continued]

Point-of-Use Demineralizing System

In few manufacturing operations is quality control so critical as in the production of semiconductors. For example, undesirable chemical residues in excess of one part in ten million are intolerable in many operations.

But it is one thing to set up such rigid specifications, another to achieve them. For instance, in the manufacture of transistors, a very serious problem is the production and circulation of water pure enough to rinse the germanium and silicon crystals before assembly. Virtually any metallic or other ions present in the rinse water will leave chemical residues which will interfere with yields, reproducible electrical characteristics, or life of the product.

Western Electric Co. considered a number of solutions at its Allentown Works in Allentown, Pennsylvania. First, piping high quality demineralized water through existing stainless steel lines from a central source, a distance exceeding 300 feet, was considered. However, it was found that the purified water tended to leach out metallic ions from the pipe and it was known that corrosion and organic matter form at the fittings, so that when the process water reached the point of use, desired minimum resistances could not be guaranteed.

Other means of distributing ultra-high purity water were tried, too, such as the use of bottled deionized water. However, problems concerned with glass dissolution during storage and increasing demands of production ruled this method out, particularly in view of the cost of bottling the water at a central location and transporting it to the separate points of use.

After further consultation, Western chemical engineers decided that the best approach was to produce water

of the specified purity right at the various points of use. It was decided this could best be accomplished by "scavenging" already demineralized water received from central source.

To implement this idea, a leading producer of demineralizing equipment, the Penfield Manufacturing Co. of Meriden, Conn., was contacted.

Together Western and Penfield worked out a water-treating system based on secondary point-of-use purification of influent with a resistance of 100,000 ohms or better received from their main demineralization units. Key to the system is a Penfield mono-column unit containing intimately mixed anion and cation resins. Designated Model T-20, this unit has a capacity of 40 g.p.h., is portable, easy to use and features plastic construction of all wetted parts. Continual monitoring of water quality by the operator is permitted through the use of electronic conductivity bridges installed right in the line. This permits an accurate measurement of water uncontaminated by air or an open container.

In actual use, the T-20 units will remove any ions remaining in the entering water to bring the resistance up as high as 18-22 megohms. Upon continuing use, this resistance will of course drop until a pre-set minimum eventually is reached.

At this point, the resin cartridge is removed and replaced with a fresh cartridge. The spent cartridge is then taken to a special Penfield Regeneration Bench where, at the operator's convenience, seven such cartridges can be regenerated at one time.

The obvious advantages of the Penfield point-of-use demineralization system is that it meets all purity specifications and permits simple, trouble-free operation. Moreover, the cost of producing ultra-high purity process water, including all equipment amortization, is very low.

Operator is shown regenerating spent resin cartridges in the Penfield SR-1 Regenerating Bench. The contents of seven T-20 canisters are regenerated at one time by a single operator who prepares the acid and caustic solutions and then sets the sequence time switch as shown in the photograph. The exhausted resins are separated, regenerated, rinsed, tested, and reloaded into their canisters, all semi-automatically.

Cascade washer which is used to rinse electron tube parts. By continuous recirculation the ultimate in water purity is achieved. Parts to be rinsed are transferred counter-current to the flow of the water with each cascade containing purer water. By this technique all water soluble chemical ions are dissolved and rinsed away. The Penfield Model T-20 in the background purifies the recirculating water to 18-22 megohms.

APPLICATIONS ENGINEERING DIGESTS

APPLICATIONS ENGINEERING DIGEST NO. 39

FM Tuner; Hughes Aircraft Co., Newport Beach, Cal. (D. English)

General Description

The tuner uses nine transistors: seven 2N1197 high frequency silicon transistors and two audio frequency germanium transistors. It consists of an *r-f* amplifier, mixer, local oscillator, three *i-f* amplifiers, a limiter, a discriminator using two Hughes 1N191 diodes, an emitter follower audio output stage, a *d-c* amplifier for the tuning indicator and an HC 7002 silicon capacitor for the *afc* element. The tuner requires a signal strength of about 10 μv or greater across the 300 ohm input for limiting and with that signal, an audio signal of about 0.5 to 1.0*v rms* is obtained at the output. The tuner operates on a +6 volt supply for the emitter bias and a collector supply of from −9 to −30 volts. Best performance is obtained at higher collector supply voltage, but the tuner should be aligned with the desired operating supply voltage, because of the variation of collector capacity with bias voltage. Total current drain from each supply is about 10 milliamperes.

Front End

The *r-f* amplifier provides about 10 *db* of gain but its main function is to increase image rejection. *T-1* matches the antenna to the input impedances of the transistor and the base is tapped down on the secondary in order to provide the loaded *Q* necessary for a bandwidth of approximately 20 *mc*. With the collector tapped down on *T-2*, a total bandwidth of about 6 *mc* is obtained for the *r-f* stage. The secondaries of *T-1* and *T-2* must be connected for phase reversal to accomplish neutralization.

The diode in the emitter circuit of the mixer is connected so that it is in the forward directon when the emitter goes in the reverse direction. This diode improves the performance of the mixer by increasing the gain and lowering the noise. The mixer gives about 10 *db* gain.

Because of the very high capacitance of the HC7002 used for *afc*, a 5 $\mu\mu f$ capacitor is connected in series with it across the local oscillator tank. The diode is self biased slightly in the reverse direction by the local oscillator signal charging C_b through the diode. When the local oscillator frequency is the correct value the discriminator *d-c* output is about zero. As the local oscillator is varied around this frequency, the *d-c* output varies from +1 volt to −1 volt. This *d-c* signal is applied to the diode via the output emitter follower. The small change in capacitance of the diode with bias is sufficient to provide a sensitive *afc*.

I-F Amplifier (Fig. 39.1)

The amplifier provides more than 60 *db* gain with a band width of about 300 *kc*. The neutralizing capacitors are made variable so that transistors of different collector capacities may be used. They may be replaced with fixed capacitors after the approximate value is found as described in the alignment instructions.

The interstage transformers, *T-3* through *T-6*, were designed to match 5,000 ohms to 250 ohms which are typical values of output and input impedances for the transistor at 10 *mc*. The secondaries of the transformers must be connected to get phase reversal from the collectors for neutralization. By using the highest possible *L/C* ratio for the primary, the band width would be in the order of several *mc* with the collector connected across the whole primary. Therefore, to get a lower bandwidth, the operating *"Q"* is increased by tapping the collector down about halfway on the primary.

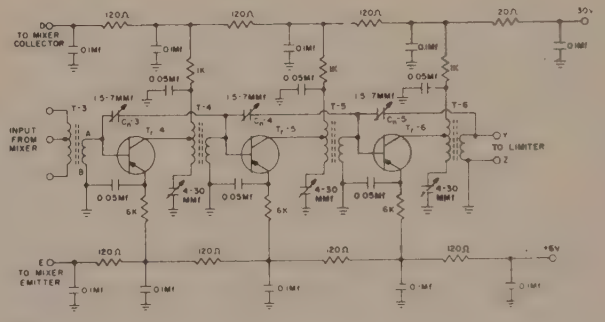

Fig. 39.1—10.5 *mc if* amplifier for *fm* tuner.

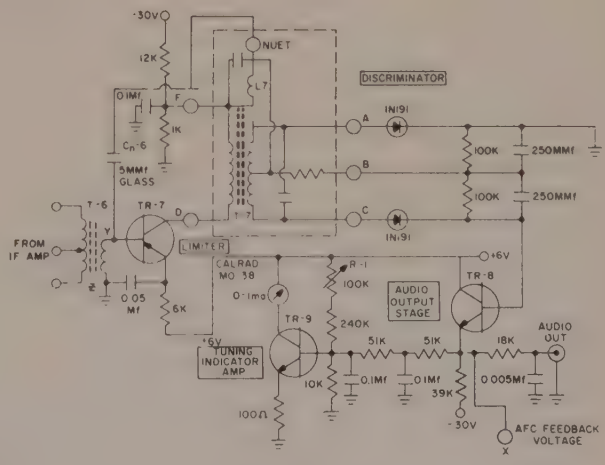

Fig. 39.2—Limiter, discriminator, audio output and tuning indicator for *fm* tuner.

Limiter, Discriminator, Tuning Indicator and Output Circuits (Fig. 39.2)

The limiter has low *d-c* collector voltage and current and the collector is alternately driven to zero voltage and zero current by the signal. The signal is thus limited to about 3 or 4 volts peak-to-peak at the collector.

The discriminator transformer is a commercial unit which has a 5-turn winding added for neutralization. This winding is connected for phase reversal from collector. The neutralization winding and capacitor have little effect on the limiter with large input signals but provide small signal stability for the stage.

The discriminator output must be taken from the side (other side grounded) which gives the proper phase for *afc* action. If connected backwards the tuner will motorboat. The procedure for determining the proper connection will be given below. For initial alignment the *afc* is disabled and the discriminator may be connected without regard to polarity. Because the output impedance of the discriminator is fairly high, an emitter follower is used to obtain a low impedance audio output.

[Circle 199 on Reader Service Card]

The emitter follower is *d-c* coupled so that the *d-c* signal for the *afc* and tuning indicator may also be taken from it. The audio signal must be filtered from the *d-c* before application to the *afc* diode. A *d-c* amplifier is used to drive the tuning indicator, a 1 milliampere miniature meter. The base bias on the indicator stage is adjusted with R_1 so that the meter reads half scale with no signal in. This stage could probably be eliminated by using a center scale (100 μamp meter with a series resistor) to monitor the *d-c* output voltage of the emitter follower.

APPLICATIONS ENGINEERING DIGEST NO. 40

Transistorized Remote Control System; Texas Instruments Incorporated, Dallas, Texas.

This application note describes a remote control system that gives good performance with inexpensive transistors. The system components, a transmitter and a receiver, are decribed separately and suggestions for adjusting the system for optimum performance are persented.

Transmitter

The transmitter consists of an *r-f* and an audio section. The *r-f* section includes a crystal oscillator and a keyed power amplifier. A free running multivibrator turns the power amplifier on and off at an audio rate.

Figure 40.1 shows the transmitter schematic. The crystal oscillator, *Q3*, is a common-base stage with feedback through the crystal taken from a tap on the collector coil. This tap position is adjusted to obtain good oscillator starting with minimum feedback. *R6*, *R7*, and *R9* are bias resistors; *R8* is a decoupling resistor; *C3* and *C4* are *r-f* bypass capacitors, while *C5* tunes the collector circuit to the 27.255-*mc* crystal frequency. Output is adjusted by positioning the *C6* tap on *L2*.

The power amplifier, *Q4*, is operated common-emitter. *R10*, *R11*, and *R12* are the bias resistors. Turning the bias voltage on and off at an audio rate keys the transmitter. *C8* and *C9* are *r-f* bypasses, *C11* is the collector tuning capacitor, and *C10* is a coupling capacitor.

The keying signal is supplied by a free-running multivibrator, *Q1* and *Q2*. *L1* prevents *r-f* from getting back into the audio circuits. Resistor *R1* equalizes the load on the multivibrator giving equal on and off times. In this circuit *R2* and *R5* are the collector load resistors; *R3* and *R4* are the base resistors; *C1* and *C2* are the cross-coupling capacitors.

Receiver

The receiver consists of an *r-f* amplifier, super-regenerative detector, quench filter, audio amplifier, audio filter, power detector, and relay. The receiver was designed for maximum performance consistent with simple circuitry.

Receiver operation is as follows: The incoming signal (a carrier in the 27-*mc* region modulated with an audio tone) is fed from the antenna to an *r-f* amplier. While providing some gain, this stage mainly serves to isolate the super-regenerative detector from the antenna, thereby helping to prevent radiation by the detector and making it much easier to adjust.

The detector operates as a self-quenched stage with the *r-f* signal fed into the collector and the audio output taken from the emitter. This stage is desirable for remote-control equipment because of its high gain and simplicity. Its lack of selectivity can be tolerated since audio filtering is used.

Output from the super-regenerative detector is a supersonic (about 50 *kc*) quench signal and the audio of the incoming signal. Rejecting the strong quench signal, the quench filter passes the audio signal to the amplifier. Without this filter, the quench signal would overload the audio stages, preventing their proper operation.

The audio signal from the quench filter is amplified in a two-stage tuned amplifier. By requiring a particular audio tone as well as the proper *r-f* signal, the amplifier discriminates against undesired signals. How this selectivity is obtained will later be discussed in detail.

The amplified audio is detected and the resulting *d-c* used to operate the relay. The relay contacts can be used to control other circuits as desired.

Figure. 40.2 is the receiver schematic. The incoming signal is amplified by *Q1*, a common-emitter amplifier. *L1-C2* and *L2-C5* are the tuned circuits for this stage. *R1*, *R2*, and *R3* provide operating bias currents for the transistor. *C1* is a coupling capacitor while *C3* and *C4* are *r-f* bypasses. The signal is coupled from *L2* to *L3*, using *C6* as a coupling capacitor. Varying the value of *C6* changes the amount of coupling. *R4* provides collector voltage for *Q1* and *Q2*.

L3, *C7* and *C8* provide a tuned circuit for the super-regenerative detector *Q2* which is operated common-base with *R5* and *C10* in an R-C quench-determining network. *C9*, which controls the regeneration, should require only an initial adjustment for maximum performance. *L4* isolates the emitter from *r-f* ground. *C10* and *C11* are *r-f* bypasses. *R6* and *R7* form the *d-c* emitter resistance with *R7* also serving as an audio gain control. *L5*, *C13* and *C14* form a low-pass filter to prevent signals at the quench frequency from overloading the audio stages.

Q3 and *Q4* comprise a two-stage tuned audio amplifier, tuned by *L6* and *C16*

(Continued on page 54)

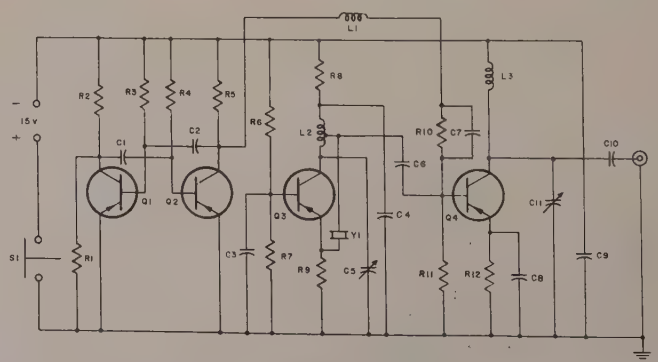

Fig. 40.1—Transmitter schematic.

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Industrial Preparedness Study Diffused Semiconductor Device	US Govt Res Repts October 16 1959 LC $9.30 PB 139436	Production of germanium transistors header fabrication, gaseous diffusion, evaporation, and alloying, etc.	E. A. Temple W. F. Bennett

APPLICATIONS [from page 50]

in a feedback circuit. At all frequencies except the resonant frequency of this *L-C* circuit the gain is kept very low by a large amount of negative feedback. The stages are direct-coupled, with *R11* and *R12* providing a feedback *d-c* bias arrangement. *C18* is an audio bypass capacitor while *C15* and *C17* are coupling capacitors.

Coupled to *Q5* through *T1*, the audio signal is rectified by the emitter-base diode and the amplified current used to operate relay *K1*. *C19* bypasses the relay and smooths the pulsating *d-c*. Contacts of *K1* may be used to actuate the necessary control equipment. *R13* keeps the voltage on *Q5* from exceeding the allowable 20 volts.

Circle 200 on Reader Service Card

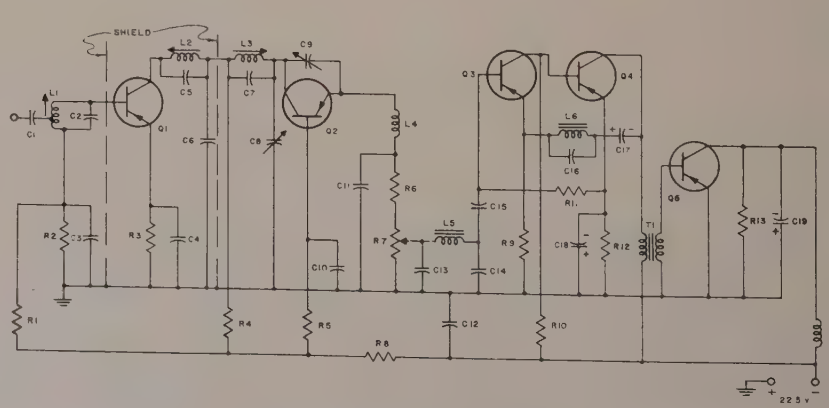


Fig. 40.2—Receiver schematic.

PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from Jan. 14, 1958 to Feb. 11, 1958. In subsequent issues, patents issued from Feb. 11, 1958 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear periodically, the treatment given to each item being more detailed.

January 14, 1958

2,820,152 Semiconductor Network—V. P. Mathis, J. J. Suran. Assignee: General Electric Company. A triggering circuit for single-junction semiconductor network, said network being discontinuously responsive to applied signals.

2,820,165 Electronic Counter Systems—H. J. Woll. Assignee: Radio Corporation of America. A counter system comprising a plurality of cascade-coupled bistable pulse transfer circuits, an advance pulse circuit, and means for triggering the bistable circuits.

2,820,154 Semiconductor Devices—J. Kurshan. Assignee: Radio Corporation of America. A device comprising a body of material having intrinsic conductivity, a set of projections on said body with slots there-between, zones of semiconductor material on the tops of said projections, and zones of opposite type at the bottom of the slots or troughs.

2,820,155 Negative Impedance Bistable Signal Operated Switch—J. G. Linvill. Assignee: Bell Telephone Laboratories. Apparatus for isolating a signal source from a load for signal voltages below a threshold value, and for establishing a low impedance signal path for said source to said load in response to signal voltages greater than the threshold value.

2,820,184 Titanate Rectifiers—J. J. Dymon. Assignee: Sylvania Electric Products. A current rectifier comprising an electrode of a partially reduced titanate of an alkaline earth metal having a lead oxide surface.

2,820,185 Semiconductor Devices And Methods of Making Same—S. M. Christian. Assignee: Radio Corporation of America. A germanium or silicon semiconductor device having a region of *n*-type material containing an excess of *n*-type over *p*-type impurity concentrations, said excess being of the order of 10^{-7} to 10^{-9}, and said impurity being bismuth.

2,820,199 Push-Pull Modulator—J. A. Greefkes. Assignee: North American Philips Co., Inc. In a modulator circuit one signal is supplied in push-pull to the emitter electrodes of the four zone transistors with an amplitude so large that the corresponding collector currents are independent of this amplitude, another signal being fed to the collectors of said transistors with an amplitude so small that the collector currents vary linearly with this amplitude.

January 21, 1958

2,820,698 Process For Purifying Silicon Halide—I. J. Krchma. Assignee: E. I. Dupont de Nemours and Co. A process consisting of the steps of adding 0.1 to 10 mols of water per 100 mols of silicon halide, agitating the mixture, separating the products resulting from the water addition, and recovering the silicon halide.

2,820,855 High Impedance Transistor Amplifier—S. Sherr. Assignee: General Precision Laboratory, Inc. A high impedance amplifier comprising a *d-c* detector, a chopper vibrator, a capacitor connected thereto, a capacitor-potential amplifier, a vibrating rectifier for the amplifier output, and means for vibrating the chopper and the rectifier in synchronism and phase.

2,820,897 Universal Gating Package—F. R. Dean, R. W. Brooks. Assignee: Computer Control Company. A universal logical package designed for interconnection and association with a plurality of identical packages for the implementation of logical operations.

2,820,930 Transistor Holders—C. E. Coy, Assignee: United States of America (Navy Dept.). A transistor mounting device comprising a body having an internal cavity, means at one end of said body for mounting the structure to a chassis, and a terminal holder for the lead wires of the transistor mounted in said cavity.

2,820,930 Transistor Holders—C. E. Coy, B. D. Tague. Assignee: United States of America (Navy Dept.). A transistor holder for a hermetically sealed device, said holder permitting the transistor to be rapidly mounted or dismounted without unsoldering the electrical connections.

2,820,931 Semiconductor Devices And Methods—F. Koury. Assignee: Sylvania Electric Products, Inc. A semiconductor device comprising a sealed envelope, contact and semiconductor elements mounted in said envelope, and a hydride desiccant in the sealed envelope producing hydrogen within said envelope upon moisture absorbtion.

8,820,932 Contact Structure—D. H. Looney. Assignee: Bell Telephone Laboratories. The method of producing a low resistance alloyed connection to a silicon body by placing upon said body a coated conductive member having alternate discrete layers of lead and silver bonded thereupon, heating the interface between the coated member and the body to between 500°C and 800°C, and cooling the device to room temperature.

2,820,941 Current Supply Apparatus—E. A. Berkery. Assignee: Bell Telephone Laboratories. Transistorized regulated switching means for supplying current to a load.

2,820,943 Minimum Time Delay Magnetic Amplifier—K. A. Sanders. Assignee: North American Aviation, Inc. A minimum time delay magnetic amplifier having either an *a-c* or a polarity-reversible, half-wave *d-c* output, or with suitable modifications, a phase-reversible *a-c* output or a polarity-reversible full wave *d-c* output.

January 28, 1958

2,821,460 Method of Purifying Silicon Tetrachloride and Germanium Tetrachloride—J. M. Whelan. Assignee: Bell Telephone Laboratories. A method of treating volatile compounds of germanium and silicon by bringing aluminum chloride into contact with said compounds and maintaining said contact until an aluminum phosphorus chlorine complex is formed.

8,821,490 Titanate Rectifiers—H. C. Dunegan. Assignee: Sylvania Electric Products, Inc. A method for producing titanate rectifiers by preparing a ceramic body composed of partially reduced alkaline earth titanates mixed with three per-cent of lanthanum, firing said body in a helium-hydrogen reducing atmosphere at a temperature of 2000°C to 2600°C, oxidizing a surface of said body and applying a metallic contact to the surface.

2,821,493 Fuzed Junction Transistors With Regrown Base Regions—J. W. Carman, Jr. Assignee: Hughes Aircraft Company. A method of producing a fused junction *n-p-n* transistor by fusing an alloy pellet to an *n*-type monatomic semiconductor specimen to convert a region of said specimen to a regrown *p*-type base region having an alloy button protruding therefrom; dissolving said allow button and fusing a second alloy pellet to said base region to reconvert a portion thereof to an *n*-type region.

2,821,639 Transistor Switching Circuits—R. L. Bright, G. H. Royer. Assignee: Westinghouse Electric Corporation. A reversing switch for coupling a source to a load wherein the terminals of the load are at no time open circuited during the reversing operation.

2,821,657 Deflecting System—R. C. Newhouse. Assignee: Bell Telephone Laboratories. A system for deflecting the electron beam of a cathode ray tube along each of a plurality of rectilinear coordinate axes in response to a particular deflecting signal for each of said axes.

2,821,674 Motor Control Circuits—G. E. Hughes. Assignee: Raytheon Manufacturing Co. A pair of transistors in grounded emitter circuits controls the flow of pulsed

*Source: Official Gazette of the U. S. Patent Office and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

d-*c* through the windings of associated magnetic amplifiers which in turn control the *a*-*c* flow through the control winding of a split phase induction motor.

February 4, 1958

2,822,250 Material Removal From Semiconductive Metal Telluride—D. de Nobel. Assignee: North American Philips Company, Inc. A method of removing material from a semiconductive body of a bivalent-metal telluride by etching a surface portion of said body.

2,822,299 Method of Making A Cadmium Telluride Semiconductive Device—D. de Nobel. Assignee: North American Philips Company, Inc. A method of providing a tellurium layer on a cadmium-telluride semiconductive body by subjecting a surface portion of said body to an oxidizing treatment.

2,822,300 Photoconductive Material—E. F. Mayer, L. Owens. Assignee: Horizons, Inc. A method of treating elemental selenium with arsenic in order to increase the spectral response, light sensitivity, and photoconductive stability of elemental selenium.

2,822,307 Technique For Multiple P-N Junctions—B. Kopelman. Assignee: Sylvania Electric Products, Inc. A junction transistor fabricating method comprising the steps of forming a stack of semiconductor slices having alternately opposite conductivity types and different melting points, heating the stack to a temperature between the melting point of the semiconductor materials, and cooling the stack after equilibrium has been reached.

2,822,308 Semiconductor P-N Junction Units And Method of Making The Same—R. N. Hall. Assignee: General Electric Co. The preparation of a melt having donor and acceptor impurity traces in amounts sufficient to provide intrinsic-type semiconductor in a crystal grown from the melt at a constant growth rate, and growing a crystal at rates continuously and cyclically varying above and below said constant growth rate.

2,822,309 P-N Junction Device and Method of Making The Same By Local Fusion —R. N. Hall. Assignee: General Electric Co. A method of producing a junction transistor having conduction characteristics of one sign and containing a first activator element for producing carriers of one sign and a second activator element for producing carriers of the opposite sign, said elements being present in a ratio of 0.5 to 1.0 times the ratio of their molecular weights times the inverted ratio of their segregation coefficients.

2,822,310 Semiconductor Device—F. H. Stieltjes, L. J. Tummers. Assignee: North American Philips Company, Inc. The device provides reduction of barrier layer leakage current and of capacitance and an increase in the breakdown voltage or of the emitter efficiency.

2,822,430 Transistor Amplifier Circuit—H. C. Lin. Assignee: Radio Corporation of America. A transistor signal amplifier circuit for an electromechanical transducer having a capacitive internal impedance, said amplifier providing for said transducer a load circuit having a large time constant in order to compensate for frequency response variation of the output current of the transducer.

2,822,434 Amplifying Apparatus—R. J. Ehret. Assignee: Minneapolis-Honeywell Regulator Co. A transistor amplifier having a constant current drain with respect to temperature variations and individual transistor characteristics, said constant current drain taking place at any given power supply voltage.

2,822,510 Series Resonant Frequency Discriminator Circuit—G. S. Epstein. Assignee: United States of America (Dept. of the Army). A discriminator circuit for use with low impedance matching devices.

2,822,520 Electric Pulse Time Modulators—J. C. Price. Assignee: International Standard Electric Corp. An arrangement comprising means for generating a train of short, regularly repeated, amplitude modulated sample pulses representing samples of the signal waves of one or more communication channels, means for storing energy corresponding to the signal wave magnitude, and a means for controlling the time of generation of an output position-modulated pulse.

2,822,522 Electric Pulse Modulators—J. C. Price. Assignee: International Standard Electric Corp. A device that employs the phenomenon of the persistence of the increase in collector current after a period during which the emitter contact is unblocked after having been previously blocked, said use of the phenomenon being for the purpose of generating pulses of controllable duration.

2,822,523 Semiconductor Angle Modulator Circuit—P. L. Bargellini. Assignee: Radio Corporation of America. An angle modulator circuit comprising a semiconductor device, a plurality of ohmic base contacts symmetrically located about the emitter, means for establishing a rotating electric field within the semiconductor body and means for driving an angle-modulated output signal from the collector.

February 11, 1958

2,822,606 Titanium Oide Rectifier And Method For Manufacturing Same—K. Yoshida. Assignee: None. A method consisting of forming a layer of titanium oxide semiconductor on a metallic titanium plate, oxidizing the surface of the titanium oxide to form a thin film oxidized to a greater extent, and fixing a counter electrode on said film.

2,823,102 Method For Producing Single Crystals of Silicon—M. L. Selker, J. F. Arness. Assignee: Clevite Corporation. A method comprising the steps of melting and cooling silicon in a non-reactive atmosphere during which process the silicon is supported on pure boron nitride powder for the nucleation of a single crystal in response to the heating and cooling steps.

2,823,148 Method For Removing Portions of Semi onductor Device Electrodes—J. I. Pankove. Assignee: Radio Corporation of America. A method for making a semiconductor device by intimately joining a metal selected from group Ib or indium, gallium, bismuth, or zinc to the surface of a body of germanium or silicon to form a *p*-*n* junction in said body, and removing all other portions of said metal from said body by dissolving said metal in mercury.

2,823,149 Process of Forming Barrier Layers In Crystalline Bodies—P. Robinson. Assignee: Sprague Electric Company. The production of a barrier layer in a semiconductive body by oxidizing a surface layer of said body, depositing a conductivity-changing element upon the oxide layer, and thermally causing said element to diffuse through the oxide layer into said body.

2,823,175 Semiconductive Devices—J. Roschen. Assignee: Philco Corporation. The fabrication of a semiconductive structure by plating a semiconductive body and its body contacting with a metallic layer which is loosely adherent to the electrode and porous in the region thereof, etching said porous part to remove it and a surface layer of the electrode, and exposing an unplated zone of said body between the electrode and the remaining portions of the plated layer.

2,823,267 Delay Circuit For Amplifying Device—L. A. Meacham. Assignee: Bell Telephone Laboratories. Apparatus that permits an amplifying device to be cut off for a predetermined period following a voltage change not necessarily related to the amplifier.

2,823,269 Transistor Amplifier Having A Variable Amplification—H. H. Van Abbe, L. J. Cock. Assignee: North American Philips Company, Inc. An amplifier having means for deriving an output voltage from the collector electrode so that the amplification of the amplifier arrangement is controlled without an excessive drop in the value of the transistor input impedance as viewed from the signal source.

2,823,312 Semiconductor Network—E. Keonjian. Assignee: General Electric Co. A network utilizing temperature sensitive resistances connected with the energy source in order to change the operating conditions of the transistor when the temperature varies, said resistors thus exerting a corrective effect upon the network frequency.

2,823,321 Gate And Buffer Circuits—J. C. Sims, Jr. Assignee: Sperry Rand Corp. A control circuit utilizing a saturable magnetic core and means for performing said saturation in a predetermined direction, a winding on said core and a plurality of rectifiers attached to said winding, means for causing forward current flow through selected rectifiers, means for reversing current in the rectifier in order to drive said core through an unsaturated region of its hysteresis loop.

2,823,322 Electronic Switch—R. B. Trousdale. Assignee: General Dynamics Corp. An electronic switch used for switching large amounts of power but which operates upon application of a relatively small amount of power.

2,823,348 Phase Lead Network—D. G. Scorgie. Assignee: None. An *a*-*c* phase lead network which, when combined with other elements in a control loop, will compensate for the lagging phase characteristics of said other circuit elements.

2,823,357 Stabilized Impedance Converter —W. W. Hall, Jr. Assignee: United States of America (Dept. of the Army). A circuit for converting a positive impedance across one terminal pair of a two pair network to a negative impedance at the other terminal pair.

[To be continued]

CHARACTERISTICS CHARTS OF NEW DIODES and RECTIFIERS

ANNOUNCED BETWEEN Dec. 1, 1959 and Jan. 31, 1960. This is a partial listing continued from the April 1960 issue.

MANUFACTURERS

AEG—	Allgemeine Elektricitats-Gesellschaft
AEI—	Associated Electrical Industries, Ltd.
AMP—	Amperex Electronic Corp.
AUD—	Audio Devices, Inc.
BEN—	Bendix Aviation Corp.
BER—	Berkshire Labs
BOG—	Bogue Electric Mfg. Co.
BOM—	Bomac Labs
BRA—	Bradley Labs
CBS—	CBS Electronics
CDC—	Continental Device Corp.
COL—	Columbus Electronics Corp.
CTP—	Clevite Transistor Products, Inc.
CSF—	Compagnie Generale de T.S.F.
DAL—	Dallons Semiconductor
DEL—	Delco Radio
EEVB—	English Electric Valve Co., Ltd.
ERI—	Erie Resistor Corp.
FAN—	Fansteel Metallurgical Corp.
FERB—	Ferranti Ltd.
GAH—	Gahagan, Inc.
GECB—	General Electric Co., Ltd.
GE—	General Electric Company, Semiconductor Div.
GELC—	Canadian General Electric Co.
GIC—	General Instrument Corp.
GTC—	General Transistor Corp.
HAFO—	Institutet for Halvedarforskning
HSD—	Hoffman Semiconductor Division
HITJ—	Hitachi Ltd., Mushashi Works
HUG—	Hughes Products Division
INRB—	International Rectifier Co., Ltd.
INRC—	International Rectifier Corp.
IRC—	International Resistance Co.
ITT—	International Tel. & Tel. Corp.
KEM—	Kemtron Electron Products, Inc.
LCTF—	Laboratoire Central de Telecommunications
MAL—	P. R. Mallory & Co., Inc.
MIC—	Microwave Associates, Inc.
MIFI—	Microfarad
MOT—	Motorola, Inc.
MUL—	Mullard, Ltd.
NAE—	North American Electronics
NPC—	Nucleonic Products Co., Inc.
OHM—	Ohmite Manufacturing Co.
PHI—	Philco Corp. Lansdale Tube Company
PLEB—	The Plessey Co.
PSI—	Pacific Semiconductors, Inc.
QSC—	International Diode Corp.
RADF—	La Radiotechnique, Div. Tubes Electroniques
RAY—	Raytheon Company
RCA—	Radio Corporation of America, Semiconductor Div.
RHE—	Rheem Semiconductor Corp.
ROSG—	Dr. Ing. Rudolph Rost
SAR—	Sarkes Tarzian, Inc., Rectifier Division
SCN—	Semicon, Inc.
SEM—	Semi-Elements Inc.
SIE—	Siemens & Halske Aktiengesellschaft
SIL—	Silicon Transistor Corp.
SONY—	Sony Corp.
SSD—	Sperry Semiconductor Division
SSP—	Solid State Products, Inc.
STC—	Shockley Transistor Corp.
STCB—	Standard Telephone & Cables, Ltd.
SYL—	Sylvania Electric Products, Inc.
SYN—	Syntron Co.
TEX—	Texas Research Assoc.
TFKG—	Telefunken, Ltd.
TI—	Texas Instruments, Inc.
TKD—	Tekade, Nurnberg, Germany
TOK—	Tokyo Tsushin Kogyo, Ltd.
TRA—	Transitron Electronic Corp.
TUN—	Tung-Sol Electric, Inc.
TSC—	Trans-Sil Corp.
UCI—	United Components
USD—	United States Dynamics Corp.
USS—	U. S. Semiconductor Products, Inc.
VIC—	Vickers Inc.
WEC—	Western Electric Co.
WEST—	Westinghouse Electric Corp.

CHARACTERISTICS CHART of SILICON ZENER or AVALANCHE DIODES

TYPE NO.	Zener or Avalanche Voltage Range			Dynamic Impedance		MAX. DISS.	TEMP. CO-EFFICIENT	MFR. (See code at start of chart)
	MIN. E_{b1} (volts)	MAX. E_{b2} (volts)	@ I_z (ma)	Z @ I_z (ohms)	(ma)	(mw)	%/°C	
1N1945	110	130	.20	2800	1.0	200		GIC
1N1946	130	160	.10			200		GIC
1N1947	160	200	.10			200		GIC
1N1948	200	240	.10			200		GIC
1N1949	240	300	.10			200		GIC
1N1950	300	360	.10			200		GIC
1N1951	360	430	.10			200		GIC
1N1952	430	510	.10			200		GIC
1N1953	510	620	.10			200		GIC
CD3131	3.13	3.47		24	20	250	.062	CDC
CD3132	3.42	3.78		22	20	250	.055	CDC
CD3133	3.7	4.1		20	20	250	.049	CDC
CD3134	4.08	4.52		18	20	250	.036	CDC
CD3135	4.46	4.94		16	20	250	.018	CDC
CD3136	4.86	5.36		14	20	250	.008	CDC
CD3137	5.32	5.88		8.0	20	250	.006	CDC
CD3138	5.89	6.51		3.0	20	250	.022	CDC
CD3139	6.46	7.14		3.0	20	250	.035	CDC
CD3141	7.12	7.88		4.0	10	250	.045	CDC
CD3142	7.79	8.61		5.0	10	250	.052	CDC
CD3143	8.64	9.56		6.0	10	250	.056	CDC
CD3144	9.5	10.5		7.0	10	250	.060	CDC
CD3145	10.45	11.55		8.0	10	250	.065	CDC
CD3146	11.4	12.6		10	10	250	.070	CDC
CD3147	12.35	13.65		12	5.0	250	.075	CDC
CD3148	14.25	15.75		14	5.0	250	.080	CDC
CD3149	15.2	16.8		16	5.0	250	.085	CDC
CD3151	17.1	18.9		18	5.0	250	.090	CDC
CD3152	19	21		20	5.0	250	.095	CDC
CD4111	8.0	8.8	10	15	10	250	.0005	CDC

CHARACTERISTICS CHART of SILICON ZENER or AVALANCHE DIODES

TYPE NO.	Zener or Avalanche Voltage Range			Dynamic Impedance		MAX. DISS.	TEMP. CO-EFFICIENT	MFR. { See code at start of chart }
	MIN. E_{b1} (volts)	MAX. E_{b2} (volts)	@ I_z (ma)	Z @ I_z (ohms)	(ma)	(mw)	%/°C	
CD4112	8.0	8.8	10	15	10	250	.001	CDC
CD4113	8.0	8.8	10	15	10	250	.002	CDC
CD4114	8.0	8.8	10	15	10	250	.005	CDC
CD4115	8.0	8.8	10	15	10	250	.010	CDC
CD4116	11.4	12.6	10	15	10	250	.002	CDC
CD4117	11.4	12.6	10	15	10	250	.005	CDC
CD4118	11.4	12.6	10	15	10	250	.010	CDC
KR52	19.8	24.2	50	4.0	50	8000	.09	FERB
KR52R	19.8	24.2	same as KR52 but reverse polarity					FERB
KR53	24.3	29.7	50	4.0	50	8000	.09	FERB
KR53R	24.3	29.7	same as KR53 but reverse polarity					FERB
KR54	29.7	36.3	50	5.0	50	8000	.09	FERB
KR54R	29.7	36.3	same as KR54 but reverse polarity					FERB
KR55	35.1	42.9	50	6.0	50	8000	.09	FERB
KR55R	35.1	42.9	same as KR55 but reverse polarity					FERB
KR56	42.3	51.7	50	8.0	50	8000	.09	FERB
KR56R	42.3	51.7	same as KR56 but reverse polarity					FERB
KR57	50.4	61.6	50	11	50	8000	.10	FERB
KR57R	50.4	61.6	same as KR57 but reverse polarity					FERB
KR58	61.2	74.8	50	14	50	8000	.10	FERB
KR58R	61.2	74.8	same as KR58 but reverse polarity					FERB
KR59	73.8	90.2	50	20	50	8000	.11	FERB
KR59R	73.8	90.2	same as KR59 but reverse polarity					FERB
KR60	90	110	50	30	50	8000	.12	FERB
KR60R	90	110	same as KR60 but reverse polarity					FERB
OAZ200	4.4	5.0	1.0	60	5.0	250		PHIN
OAZ201	4.8	5.4	1.0	50	5.0	250		PHIN
OAZ202	5.3	6.0	1.0	25	5.0	250		PHIN
OAZ203	5.8	6.6	1.0	6.0	5.0	250		PHIN
OAZ204	6.4	7.2	1.0	4.0	5.0	250		PHIN
OAZ205	7.1	7.9	1.0	4.0	5.0	250		PHIN
OAZ206	7.7	8.7	1.0	4.0	5.0	250		PHIN
OAZ207	8.6	9.6	1.0	4.0	5.0	250		PHIN
OAZ208	3.3	5.0	1.0	65	5.0	250		PHIN
OAZ209	4.4	6.0	1.0	50	5.0	250		PHIN
OAZ210	5.3	7.2	1.0	6.0	5.0	250		PHIN
OAZ211	6.4	8.7	1.0	4.0	5.0	250		PHIN
OAZ212	7.7	10.6	1.0	4.0	5.0	250		PHIN
OAZ213	9.4	15	1.0	12	5.0	250		PHIN
PS1171	1.43	1.58	20	9.0	20	500	3.5	PSI
PS1172	1.52	1.68	20	12	20	500	3.5	PSI
PS1173	1.71	1.89	20	18	20	500	3.5	PSI
PS1174	2.09	2.31	20	12	20	500	4.8	PSI
PS1175	2.28	2.52	20	18	20	500	4.8	PSI
PS1176	2.57	2.84	20	27	20	500	4.8	PSI
PS1177	2.85	3.15	20	18	20	500	6.4	PSI
PZ10A	9.1	11	200	1.2	200	10W	.07	SOIF
PZ12A	11	13	160	2.0	160	10W	.075	SOIF
PZ15A	13	16	130	4.0	130	10W	.08	SOIF
PZ18A	16	20	110	7.5	110	10W	.085	SOIF
PZ22A	20	24	91	12	91	10W	.09	SOIF
PZ27A	24	30	75	15	75	10W	.095	SOIF
PZ33A	30	36	62	18	62	10W	.10	SOIF
PZ39A	36	43	51	20	51	10W	.10	SOIF
PZ47A	43	51	43	22	43	10W	.10	SOIF
PZ56A	51	62	36	24	36	10W	.10	SOIF
PZ68A	62	75	30	26	30	10W	.10	SOIF
PZ82A	75	91	24	28	24	10W	.10	SOIF
SX561	4.9	6.5	5.0	7.0	20	300	.00	GEC
SZT1 ☐	4.9	6.5	5.0	7.0	20	300	.01 max	GECB
SZT2 ☐	5.3	5.9	5.0	7.0	20	300	.001max	GECB
VR7A	6.4	7.6	20	1.5	20	5000		AEI
VR7B	6.4	7.6	20	1.5	20	2000		AEI
VR8A	7.4	8.6	20	1.5	20	5000		AEI
VR8B	7.4	8.6	20	1.5	20	2000		AEI
VR9A	8.4	9.6	20	1.6	20	5000		AEI
VR9B	8.4	9.6	20	1.6	20	2000		AEI
VR10A	9.4	10.6	20	2.5	20	5000		AEI
VR10B	9.4	10.6	20	2.5	20	2000		AEI
VR11A	10.4	11.6	20	4.0	20	5000		AEI

☐ Revised specifications

CHARACTERISTICS CHART of SILICON ZENER or AVALANCHE DIODES

TYPE NO.	Zener or Avalanche Voltage Range			Dynamic Impedance		MAX. DISS.	TEMP. CO-EFFICIENT	MFR. (See code at start of chart)
	MIN. E_{b1} (volts)	MAX. E_{b2} (volts)	@ I_z (ma)	Z @ I_z (ohms)	(ma)	(mw)	%/°C	
VR11B	10.4	11.6	20	4.0	20	2000		AEI
VR12A	11.4	12.6	20	7.0	20	5000		AEI
VR12B	11.4	12.6	20	7.0	20	2000		AEI
VR35A	2.9	4.1	20	17.2	20	5000		AEI
VR35B	2.9	4.1	20	17.2	20	2000		AEI
VR425A	3.9	4.6	20	16	20	5000		AEI
VR425B	3.9	4.6	20	16	20	2000		AEI
VR475A	4.4	5.1	20	14.4	20	5000		AEI
VR475B	4.4	5.1	20	14.4	20	2000		AEI
VR525AA	4.9	5.6	20	12.8	20	5000		AEI
VR525AB	4.9	5.6	20	12.8	20	2000		AEI
VR525BA	4.9	5.6	20	10	20	5000		AEI
VR525BB	4.9	5.6	20	10	20	2000		AEI
VR575AA	5.4	6.1	20	5.8	20	5000		AEI
VR575AB	5.4	6.1	20	5.8	20	2000		AEI
VR575BA	5.4	6.1	20	3.0	20	5000		AEI
VR575BB	5.4	6.1	20	3.0	20	2000		AEI
VR625A	5.9	6.6	20	1.8	20	5000		AEI
VR625B	5.9	6.6	20	1.8	20	2000		AEI

CHARACTERISTICS CHART of SWITCHING DIODES

TYPE NO.	MAT	PIV	MAX. CONT. REV. WORK. VOLT.	Min. Forward Current @ 25°C		Reverse Impedance @ 25°C		Recovery Characteristics				MFR. (See code at start of charts)
				I_f @ E_f		Z	VOLTAGE RANGE E_{b1} to E_{b2}	TEST CONDITIONS Fwd. I_f to Rev. E_b		$Z_{rec.}$ @ time (t)		
		(volts)	(volts)	(mA)	(volts)	(K ohms)	(volts)	(ma)	(volts)	(K ohms)	(usec)	
1N891	Si	60	50	60	1.0	.10	50	5.0	40	80	.30	GIC
1N892	Si	120	100	50	1.0	.10	100	5.0	40	80	.30	GIC
1N893	Si	240	200	50	1.0	.10	200	5.0	40	80	.30	GIC
1N914	Si	75	75	10	1.0	.025	20	10	6.0	6.0	.004	RHE
1N916	Si	75	75	10	1.0	.025	20	10	6.0	6.0	.004	RHE
1S77	Ge		60	25	1.0	250	60					HITJ
1S78	Ge		40	50	1.0	200	40					HITJ
1S79	Ge		20	8.0	.50	200	20					HITJ
CD2116	Si		85	4.0	1.5	.10	50	5.0	10	25	.15	CDC
CD2117	Si		160	6.0	1.0	.05	50	30	35	400	.30	CDC
CD2118	Si		200	50	1.0	.01	50	5.0	40	80	.30	CDC
CD2119	Si		130	10	1.0	.01	50	5.0	40	80	.30	CDC
CG80H	Ge	100	100	100	1.1	100	100	10	10		1.0	AEI
CG81H	Ge	75	75	100	1.1	75	75	10	10		1.0	AEI
CG82H	Ge	50	50	100	1.1	50	50	10	10		1.0	AEI
CG83H	Ge	25	25	100	1.1	25	25	10	10		1.0	AEI
ED1806	Ge		70	1.5	1.0	50	10 at 55°C	30	35	50	.50	ERI
ED1872	Ge	100	90	5.0	1.0	25	10	30	35	50	.30	ERI
ED1890	Ge	20	15	10	1.0	25	10	15	15	50	.40	ERI
MA4230	Si	40		10	1.0	.015	30	10	5.0		4.0m	MIC
MA4238	Si	40		20	1.0			10	5.0		4.0m	MIC
OA7	Ge	15	15	10	.42	.75	10	5.0	5.0		.10	PHIN, AMP
OA9	Ge	25	25	10	.32	3.3	25	5.0	5.0		.10	PHIN, AMP
OA47	Ge	15	15	10	.40	4.5	10	5.0	5.0		.10	PHIN
OA80	Ge	60	60	30	3.0	92	60	30	35		.10	PHIN
OA92	Ge	15	15	3.0	.60	2.5	10					PHIN
RD2266	Si	20	20	10	1.5	1.0	6.0	10	6.0	2.0	.004	RHE
SC7C			90	40	1.0	200	1.0			50	.40	SEM
SC7D			90	40	1.0	200	1.0			50	.40	SEM
SX780	Si	25	25	10	1.5	25	100	10	20	1.0	.02	GECB
SX781	Si	60	60	10	1.5	60	100	10	20	1.0	.02	GECB
SX782	Si	120	120	10	1.5	120	100	10	20	1.0	.02	GECB
ZS40	Si		25	10	1.25	.50	25	10	10	10	20m	FERB
ZS41	Si		50	10	1.5	.50	50	10	10	10	20m	FERB
ZS42	Si		100	10	1.5	.50	100	10	10	10	20m	FERB

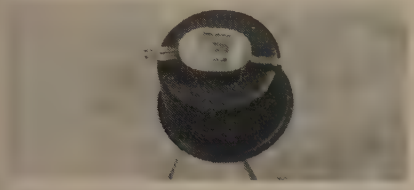
VOLTAGE VARIABLE CAPACITOR DIODES

TYPE NO.	CAPACITANCE C @ Eb		PIV	Q @ FREQ.		MFR.
	(uuf)	(volts)		Min. Q	(mc)	
BA102	20-45	4.0	20	30	50	PHIN
CS10	10	4.0	25	20	50	GIC
CS10A	10	4.0	100	15	50	GIC
CS15	15	4.0	25	20	50	GIC
CS15A	15	4.0	100	15	50	GIC
CS20	20	4.0	25	20	50	GIC
CS20A	20	4.0	100	15	50	GIC
CS30	30	4.0	25	18	50	GIC
CS30A	30	4.0	100	13	50	GIC
CS40	40	4.0	25	18	50	GIC
CS40A	40	4.0	100	13	50	GIC
CS50	50	4.0	25	16	50	GIC
CS50A	50	4.0	100	11	50	GIC
CS60	60	4.0	25	16	50	GIC
CS60A	60	4.0	75	11	50	GIC
CS70	70	4.0	25	14	50	GIC
CS70A	70	4.0	75	10	50	GIC
CS80	80	4.0	25	14	50	GIC
CS80A	80	4.0	50	10	50	GIC
CS90	90	4.0	25	13	50	GIC
CS90A	90	4.0	50	9.0	50	GIC
CS100	100	4.0	25	12	50	GIC
CS100A	100	4.0	50	8.0	50	GIC
D4075	4.5	6.0		1.0	10K	SYL
D4075A	3.0	6.0		2.0	10K	SYL
D4075B	2.0	6.0		3.0	10K	SYL
D4075C	1.8	6.0		4.0	10K	SYL
D4075D	1.4	6.0		5.0	10K	SYL
D4075E	1.0	6.0		6.0	10K	SYL
D4075F	1.0	6.0		7.0	10K	SYL
D4075G	1.0	6.0		8.0	10K	SYL
D4075H	1.0	6.0		9.0	10K	SYL
D4110	4.5	6.0		1.0	10K	SYL
D4110A	3.0	6.0		2.0	10K	SYL
D4110B	2.0	6.0		3.0	10K	SYL
D4110C	1.8	6.0		4.0	10K	SYL
D4110D	1.4	6.0		5.0	10K	SYL
D4110E	1.0	6.0		6.0	10K	SYL
D4110F	1.0	6.0		7.0	10K	SYL
D4110G	1.0	6.0		8.0	10K	SYL
D4110H	1.0	6.0		9.0	10K	SYL
HS109	20	10	20	3.0	240	HITJ
MA301	13	10	35	40	25	MATJ
MA302	20	10	35	40	25	MATJ
MA303	30	10	35	40	25	MATJ
MA450A △	2.1	6.0	6.0	2.0	10K	MIC
MA450B △	1.5	6.0	6.0	3.0	10K	MIC
MA450C △	1.1	6.0	6.0	4.0	10K	MIC
MA450D △	.80	6.0	6.0	5.0	10K	MIC
MA450E △	.60	6.0	6.0	6.0	10K	MIC
MA450F △	.60	6.0	6.0	7.0	10K	MIC
MA450G △	.60	6.0	6.0	8.0	10K	MIC
MA450H △	.60	6.0	6.0	9.0	10K	MIC
MA4202X	2.0 max	0		10	35K	MIC
MA4203X	6.0 max	0		10		MIC
MA4253X	1.4 max	0		10	120K	MIC
MA4254X	1.4 max	0		10	100K	MIC
MA4259X	4.0 max	5.0				MIC
MA4260X	6.0 max	5.0				MIC
MA4261X	8.0 max	5.0				MIC
MA4279X	.20 max	6.0				MIC
MA4280X	.40 max	6.0				MIC
MA4281X	.80 max	6.0				MIC
MA4282X	1.6 max	6.0				MIC
MA4283X	2.0 max	6.0				MIC
MA4284X	3.0 max	6.0				MIC
MA4285X	5.0 max	6.0				MIC
MA4286X	7.0 max	6.0				MIC
MA4287X	10 max	6.0				MIC
MA4288X	15 max	6.0				MIC
MA4289X	20 max	6.0				MIC
MA4290X	25 max	6.0				MIC
MA4291X	30 max	6.0				MIC
MA4292X	35 max	6.0				MIC
MA4296	2.0 max	0		10	120K	MIC
MA4298	2.0 max	0		10	150K	MIC

△—Double ended varactor

New Products

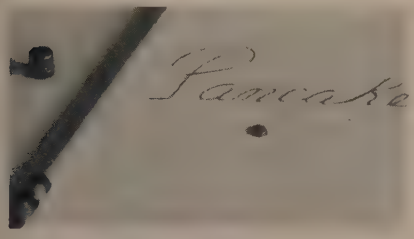
Transistor Enclosure



The Lansdale Division of Philco Corporation recently described a new microminiature transistor enclosure small enough to permit component densities on the order of 1,000,000 parts per cubic foot. The enclosure is a flat package measuring 0.125 inch wide, 0.180 inch long, and 0.060 inch high. About 42 such enclosures can be mounted on one square inch multi-element wafer, and still add only about 1 1/16 inch to its thickness. The design significantly features a cold welded, metal-to-glass, hermetically sealed package providing a minimum seal length of 0.050 inch. It will house any type of standard computer transistor.

Circle 180 on Reader Service Card

New Transistor Package



Sylvania Electric Products Inc. has announced the "Pancake" construction, a new concept in transistor packaging, which "will result in a line of miniaturized transistors, one-tenth the size and weight of conventional units." Developed for the latest microminiaturized circuitry, the height dimension has been reduced to one-twentieth of an inch, resulting in a wafer-thin semiconductor package with extreme ruggedness, reliability, and ease of manufacture. In addition, the diameter of the new package (.250-inches) is approximately 25 per cent less than conventional units.

Circle 143 on Reader Service Card

Moldable Ceramic Material

A moldable ceramic tooling material suitable to 3000° F., called Duramic S-2, is now available from Duramic Products, Inc. It is readily molded using a slip casting technique in plastic molds. No special equipment is required. S-2 has already found a wide variety of applications in high temperature processing such as brazing and welding fixtures, hot forming dies, sintering boats, diffusion boats, etc.

Circle 149 on Reader Service Card

Curve Tracer

A new Tunnel Diode Curve Tracer has been introduced by Texas Instruments Incorporated. It was developed and is being manufactured by the Instrumentation product group of TI's Geosciences & Instrumentation division. The instrument permits the study of forward characteristics of tunnel diodes made by various manufacturers, including gallium arsenide tunnel diodes recently introduced by Texas Instruments. A plug-in adapter can be changed to accommodate different package configurations.

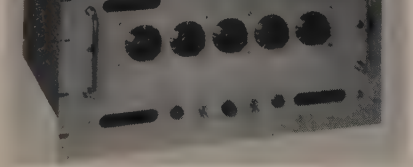
Circle 181 on Reader Service Card

Zener Diodes

A line of what was described as highly reliable, temperature-stable silicon zener diodes for voltage regulation is available from the semiconductor division of Hughes Aircraft Company. The series, designated as type IN702 through IN724, provides a dynamic resistance ranging from 10 ohms to 60 ohms for diodes of low voltage types, and from 3.6 ohms to 60 ohms for diodes of medium voltage types. Operating range is from —65°C to 175°C.

Circle 167 on Reader Service Card

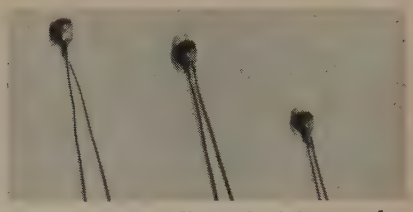
Meter Calibrator



A programmable constant current source has been introduced by North Hills Electric Company, Inc., designed especially for meter calibration, transistor and diode forward testing, and as a filament current source. Model CS-12 Current Governor furnishes currents from 10 μa to 1 amp. for load voltages from 0-7 volts. The unit is 19" x 10½" x 18" and weighs 45 lbs.

Circle 160 on Reader Service Card

Subminiature Selenium Diodes



A new and smaller subminiature plastic encapsulated selenium diode has been developed by Radio Receptor Co., Inc., (Selenium Division), a subsidiary of General Instrument Corporation. The new diodes come in eight types, with peak voltage ranges up to 400 volts at 3.75 ma. They are capable of operating in ambient temperatures from —50°C to +100°C without derating.

Circle 162 on Reader Service Card

Controlled Rectifiers And Switches

A broad line of *p-n-p-n* controlled rectifiers and switches has been introduced by Transitron Electronic Corporation. It includes: a bi-stable silicon computer element called the Transwitch which has the capability of being able to be turned off with a gate current; and silicon controlled rectifiers in both the 7/16" hex and 11/16" hex base packages. The Transwitch eliminates the need for the two transistor "flip-flop" design, greatly reducing size and number of components. The rectifiers can replace thyratrons and magnetic amplifiers in many applications and offer increased reliability and efficiency, and have greatly reduced size and weight requirements.

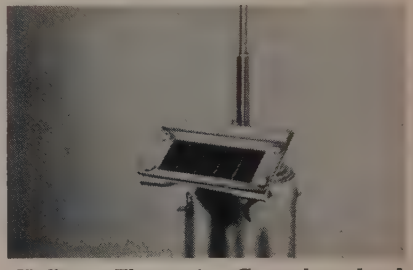
Circle 145 on Reader Service Card

Silicon Rectifiers

Cornell-Dubilier Electric Corporation is producing silicon rectifiers for medium power applications up to a maximum of 6 amperes. Available in 1/2" hex ceramic insulated or 7/16" hex styles, they are offered in eight PIV ratings from 50-600 volts. Complete electrical and mechanical characteristics are described in Bulletin SC1006.

Circle 141 on Reader Service Card

Solar-Powered Transmitter



Hoffman Electronics Corp. has developed the "safety satellite," a miniature transmitter that uses sunlight as its power source. It is the basic unit in the company's new emergency calling system designed specifically to offer a means of communication for motorists stranded on freeways, turnpikes and other superhighways. Five tiny silicon solar cells draw enough energy from the sun to keep recharging the batteries so they never need replacing, even in areas where there is no sunlight for extended periods.

Circle 157 on Reader Service Card

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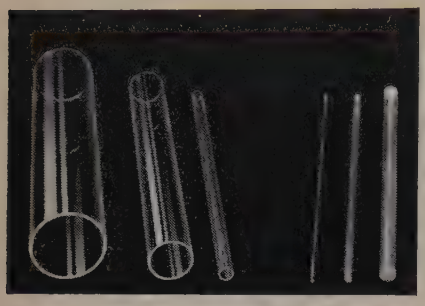

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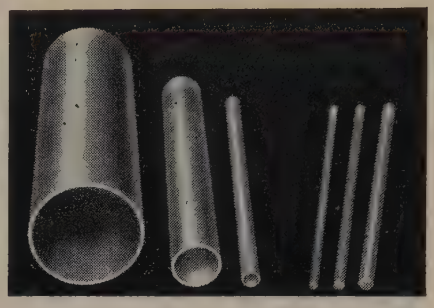
Can be secured from stock in a complete range of sizes—special sizes also avialable to meet your exact specifications.



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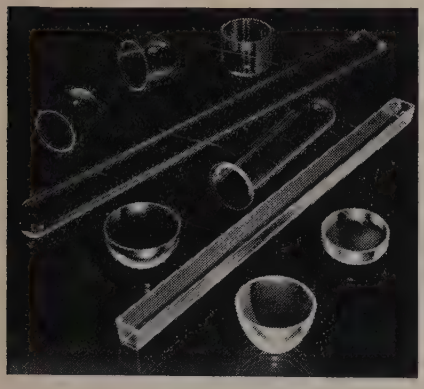

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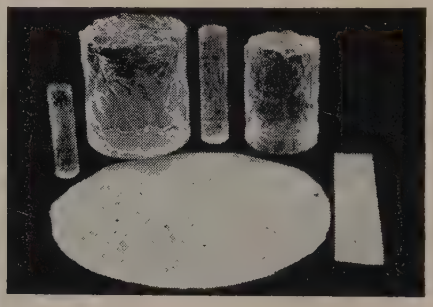

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Circle No. 62 on Reader Service Card

Crystal Filter Transformer

Type 2000 series miniature hybrid transformer for use in crystal filters was announced by Allen Avionics. Units are epoxy cased with printed circuit construction. Operating temperature is from −55 to +125°C with temperature coefficient as low as −40 ppm/°C. Frequency range from 50 KC to 50 megacycles, high "Q," tight coupling, controlled "L" ratios.
Circle 142 on Reader Service Card

Tube Furnace

A new vertical tube furnace, incorporating Kanthal Super heating elements, and designed for an operating temperature range to 1600°C has been announced by the Pereny Equipment Company, Inc. Model MTKS-312 incorporates a 3" I.D. x 30" impervious Mullite tube with the Kanthal Super heating elements mounted vertically and parallel to its main axis. Hot zone is 12" long. A vertical-lift, loading column is counter-balanced for manual operation. Power requirements are 9 KW, 220 volt, 60 cycle, single phase.
Circle 170 on Reader Service Card

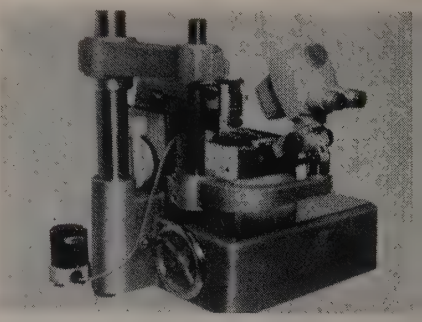
Subminiature Tantalum Capacitor

The development of a subminiature solid state tantalum capacitor has been announced by U. S. Semiconductor Products. The TSP-2 measures only 0.438 inches long and 0.172 inches in diameter while offering a capacitance of up to 5.6 mfd, a 50 volt rating and leakage current of only 0.01 microamps per mfd per volt. In addition, Semcor has developed 22 other tantalum capacitor devices in this new TSP line ranging from 6 to 50 volts and all having these low leakage current specifications.
Circle 144 on Reader Service Card

Encapsulating Machine

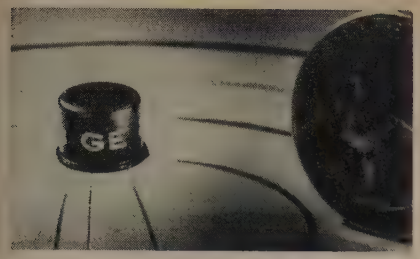
The Standard press division of Hull Corporation introduces the new Model 359D "Encapsulating machine." Designed primarily for use with the latest epoxy molding compounds, the press handles a complete range of thermosetting materials. The 25 ton Combination Compression and Transfer press offers exceptional economy in both development and production. Users report successful encapsulation of units which range from transformers to coils, semi-conductors to RF Chokes, resistors to capacitors.
Circle 177 on Reader Service Card

Semiconductor Wafer Scriber



Kulicke and Soffa Mfg. Company's new semiconductor wafer scriber is used for scribing semiconductor slices in preparation for dicing. Model 710 is a manual model. Model 700 is an automatic model.
Circle 158 on Reader Service Card

Germanium Transistors



General Electric has introduced high speed germanium *n-p-n* switching transistors, types 2N1288 and 2N1289. They are capable of operation at a frequency of 60-megacycles, have guaranteed collector to emitter voltage ratings of 10-volts and 15-volts respectively; both have emitter to base guaranteed ratings of 5-volts, and collector to base guaranteed ratings of 15-volts and 20-volts respectively. They are rated for operation in the temperature range of −55°C to +85°C.

Circle 178 on Reader Service Card

Pickup System

Penfield Manufacturing Co. has announced the availability of a device for the handling of minute parts (such as germanium and silicon crystals) used in the manufacture of semiconductors and other electronic assemblies. Called the Penfield Pickup, the newly developed pencil-shaped device operates on direct pressure. Sufficient negative pressure to attract and hold a desired particle is developed at the pick-up point, the unsharpened end of a standard hypodermic needle which can vary in diameter to accommodate particles of differing sizes.

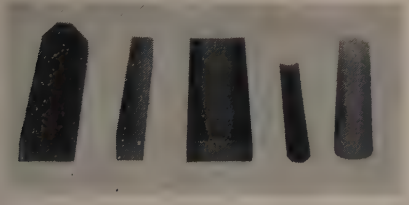
Circle 174 on Reader Service Card

Refrigerated Bath

Blue M's Magni-Whirl Refrigerated Baths, now equipped with Power-O-Matic 60 control system, suggest four basic advantages. Employs a Saturable Power Reactor Control without contacts, moving parts, or auxiliary mechanisms to wear, burn or arc. One self-contained bath covers entire range below and above ambient. Automatic, built-in agitation eliminates need for motors, stirrers and circulating pumps. Has double-wall type construction stainless steel, including cabinet-type stand.

Circle 179 on Reader Service Card

Precious Metals



Five new, special processed shapes in a variety of precious metals are now being introduced by Consolidated Reactive Metals, Inc. These processed shapes are available in such precious metal alloys as karat gold, platinum and silver. They can also be supplied in rare earth metals as well. In addition, the company announces that it now can supply special shapes in any alloy in the non-ferrous field for electronic and electrical applications. This material can be furnished vacuum annealed and outgased to reduce gas levels to an absolute minimum. Alloys can be compounded to customers' specifications if so desired.

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- Ingots with 1 ohm centimeter resistivity can now be measured with the new LM-2 Lifetime Tester without the use of a pre-amplifier.
- Simple operation and fast results make this equipment exceptionally suitable for Production Testing of Semiconductor materials.

MODEL	SPARK POTENTIAL	APPROX. CARRIER INJECTION PER CUBIC CENTIMETER	PRICE
LM-1	10 KV	10^{13}	$1,250.00*
LM-2	20 KV	5×10^{13}	$1,750.00*
LM-3	30 KV	10^{14}	$2,250.00*

*Slightly higher for 50 cycle operation.

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The Light Source consists of a stabilized spark gap, a special non-inductive capacitor charge by a variable high voltage supply through a resistor to the firing voltage of the spark gap. The resulting light flash is focused by a lens onto any point above the table. Flash duration is approximately 0.3 micro-seconds. These Light Sources are the same as those used in our Lifetime Testing Equipments. Light Source complete with table, stand and power supply.

MODEL	SPARK POTENTIAL	APPROX. CARRIER INJECTION PER CUBIC CENTIMETER	PRICE
LS-1	10 KV	10^{13}	$ 850.00*
LS-2	20 KV	5×10^{13}	$1,250.00*
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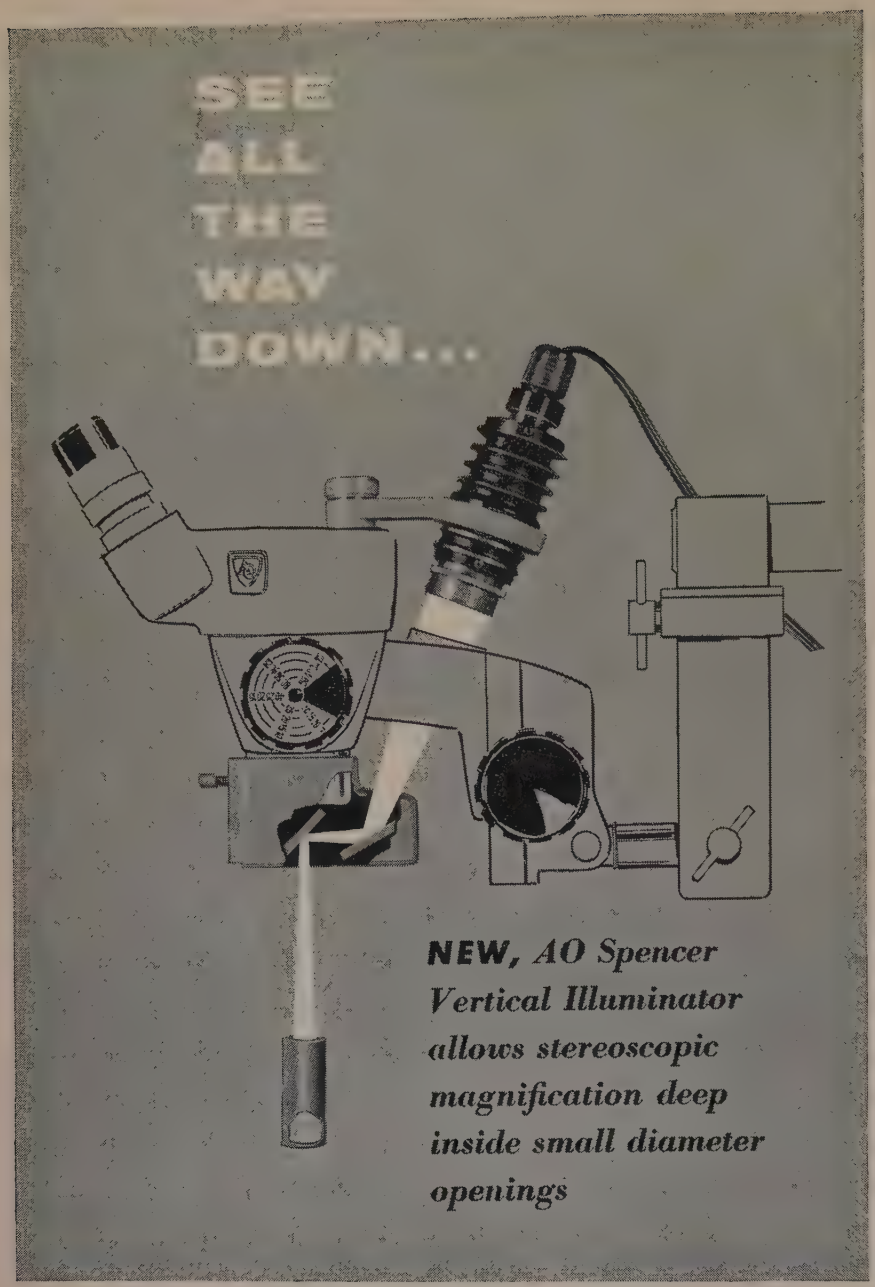

The new Vertical Illuminator and the AO Spencer Cycloptic Stereoscopic Microscope make a unique team that can be the answer to your problem whether it's the inspection of detail in small diameter, deep hole borings, or delicate assembly of miniaturized parts where every move is critical.

This low-cost illuminator readily attaches to the Cycloptic to provide efficient, shadowless illumination deep inside small orifices...and the Cycloptic delivers realistic, erect, true three-dimensional magnification of the illuminated detail.

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Silicon Mesa Transistors

A series of higher current, fast switching silicon mesa transistors has been announced by Rheem Semiconductor Corporation. RT5001 through RT5004, in addition to having current capability of 1 ampere, are rated up to 100 volts and have an extremely low saturation resistance that is typically less than 3 ohms at 500 mA. A wide range of applications is possible due to controlled beta linearity, and the fact that typical *d-c* current gain is within 75% of the maximum value from 100 milliamperes to 1 ampere.

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Bench Welding Head

A new air-operated welding head for the production welding of small parts has been developed by Ewald Instruments. Model WHD 4AP head has electrode pressure adjustable from 1 to 20 lbs. indicated on a calibrated scale. The pressure arm moves in linear ball bushings and has very low inertia (4 oz) to insure fast follow-through forging action. The head can be used with stored energy power supplies up to 200 watt-seconds or AC welders up to 2½ KVA at welding times up to 10 cycles.

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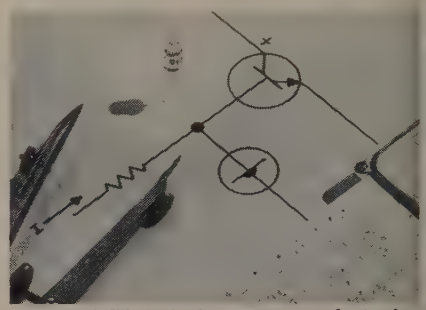
Germanium Tunnel Diodes



General Electric is now manufacturing two new germanium tunnel diodes designed for use as circuit reference elements. 1N2969 has a typical peak point current of 2.2-milliamperes and 1N2941 has a typical peak current of 4.7-milliamperes. Both devices have typical peak to valley current ratios of 8 to 1, typical peak point voltages of 55-millivolts, typical valley point voltages of 350-millivolts, and typical forward peak point current voltages of 500-millivolts. They are rated for operation over an ambient temperature range from −55°C to +100°C.

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Vacuum Valves

A new complete line of compact pneumatically operated vacuum valves is now available from Veeco Vacuum Corp. Designated type "PV," these valves are bellows-sealed construction and are available in ⅝", 1" and 1½" port size. Available for either right angle, or in-line application, the valve can be mounted either vertically or horizontally and can be obtained with either pipe thread or solder connections.

Circle 173 on Reader Service Card

Decade Amplifier

H. H. Scott, Inc., announces a new Decade Amplifier, Model 140-B, featuring response from 1 cycle to over 3 megacycles, 40 volt output and 10 megohm input impedance. It has a very low noise level, and low output impedance; its self-contained power supply is electronically regulated. Gain of 1, 10, 100 and approximately 700 is selected by switch. This instrument has found wide application by semiconductor device manufacturers for testing and production sorting.

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Time Delay Relays

Marstan Electronics Corp. Solid State Time Delay Relays are units of fixed or adjustable versions having nominal accordance of ±1% and ±5% in the time period of 0.5-110 seconds over the temperature range of −20°C to +85°C. Current ratings of 2 and 5 amps are available with voltage inputs of 6-250 volts ac or dc. The timing accuracy is maintained when the unit is subjected through a voltage variation of up to 30% of nominal value.

Circle 176 on Reader Service Card

New Oscilloscope

A differential-input X-Y oscilloscope with sensitivity of 1 mv/cm, the Type 503 introduces Tektronix quality to the dc-to-450 kc range. It is compact, dependable, easy-to-operate. It utilizes a minimum number of tubes (equivalent 17 plus rectifiers) for the maximum degree of reliability. Vertical and horizontal amplifiers are identical. Characteristics include: input stages electronically regulated, calibrated steps to 20 v/cm, adjustable between 14 steps and to over 50 v/cm uncalibrated, differential input and constant input impedance (for easy probe use) at all sensitivities.

Circle 168 on Reader Service Card

Silicon Mesa Transistor

A general purpose *n-p-n* silicon mesa transistor, type 2N752, has been introduced by National Semiconductor Corporation, for all small signal applications to 200 mc. It has high gain at frequencies up to 200 mc and at collector-emitter currents up to 100 ma. Device dissipation is 300 mw in free air. Minimum collector to emitter of 45 v, and emitter to base of 8 v is guaranteed. Leakage current is only 5 microamps at +150°C, and collector-base capacitance only 5 micromicrofarads.

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Yttrium Single Crystals

Gallium substituted yttrium iron garnet single crystals are now being commercially produced by Microwave Chemicals Laboratory, Inc. These single crystals are expected to find application in the low frequencies of the microwave region. Two single crystal types are now available. One type has a saturation magnetization of 1000 gauss/cc while the other has 600 gauss/cc. The Curie temperature being 206 ±2°C and 160°C respectively.

Circle 156 on Reader Service Card

Water-Based Fluxes

London Chemical Co., Inc. announces new non-resinous water-based fluxes featuring instantly soluble and non-charring residues. Known as Lonco Organo-Fluxes, they are available in four grades to provide sufficient activity for any job, while holding residues to an absolute minimum for the soldering speed required. Typical applications include transistors, diodes, ceramic parts, magnets, etc. They are packaged in one-gallon bottles, five-gallon cubitainers and 55-gallon lined drums.

Circle 140 on Reader Service Card

Cladding Process

A new cladding process for the manufacture of laminated precious metals, base metals and refractory metals for components of semiconductor devices has recently been developed by Composite Industrial Metals Inc. This process enables wrought metals to be bonded together in the solid state without the use of a bonding agent at the interfaces. Purity of the metals and oxide free interfaces result in increased production yield of semiconductor devices.

Circle 147 on Reader Service Card

Environmental Enclosure

A portable controlled environment enclosure is the newest accessory in The Sheffield Corporation's line of instruments and systems for precision inspection and assembly. The 16′ x 24′ x 13′ high enclosure, called a "Pre-Fab-Lab" controls temperature to within one-quarter of a degree Fahrenheit and relative humidity to less than 50 percent. It can be knocked down and set up in 24 hours to provide a truly transferable enclosure that can be moved about a plant at will.

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Industry News

CONFERENCE CALENDAR

The Following July 1960 Meetings Are Scheduled:

July 6-16	Meeting on High Energy Nuclear Physics, University of Rochester, Rochester, N. Y.
July 24-28	American Electroplaters Society, 47th Annual Convention, Hotel Statler, Los Angeles.
July	International Conference on Electronic Engineering Education, Sagamore Conference Center, Syracuse University, Syracuse, New York. Sponsored By PGE, AIEE, ASEE. For Information: Dr. John G. Truxal, Polytechnic Institute of Brooklyn, 333 Jay Street, Brooklyn, New York.
July	3rd International Conference on Medical Electronics, London, England. Sponsored By: PGME, IFME. For Information: Dr. L. K. Lusted, University of Rochester Medical School, Rochester, New York.

The establishment of an annual F. S. Kipping Award in Organosilicon Chemistry under the auspices of the American Chemical Society was announced jointly by W. R. Collings, president of Dow Corning Corporation, the sponsor, and by the Board of Directors of the American Chemical Society. One thousand dollars will be given to a scientist for distinguished contribution to knowledge of organosilicon compounds. The selection will be made by a committee of the American Chemical Society and will be open to scientists engaged in non-commercial research anywhere in the world.

RESEARCH & DEVELOPMENT

Norton Company, Worcester, Mass., has successfully made abrasive quality diamonds, Milton P. Higgins, president, stated recently. This announcement confirms statements to this effect which appeared in the South African press last year. No commercial production is anticipated at the present time.

The company is celebrating its 75th Anniversary and a series of events was held recently to commemorate this occasion. One of these was "Editors' Day" which included plant tours and discussions of the numerous achievements of the company, both past and present.

General Thermoelectric Corporation, Princeton, N.J., has developed a semiconductor quaternary alloy for thermoelectric applications. Known as Neelium, it consists of bismuth, tellurium, selenium and antimony. The Neelium compound is used in the fabrication of thermocouples, the smallest complete thermoelectric units. A module, consisting of eight thermocouples is called a Frigistor and is claimed to be the smallest of the thermoelectric modules. Its efficiency is rated at more than twice that of comparable units, according to the company. Typical applications for Frigistors which are now available

(*Continued on page 68*)

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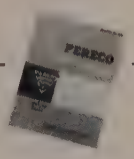
Pereco builds standard or special furnaces for temperatures from 450°F to 5000°F.



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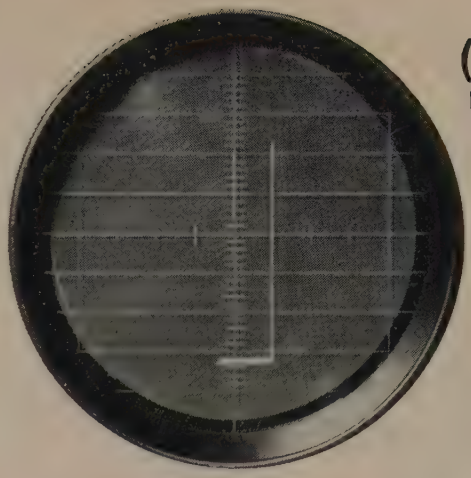
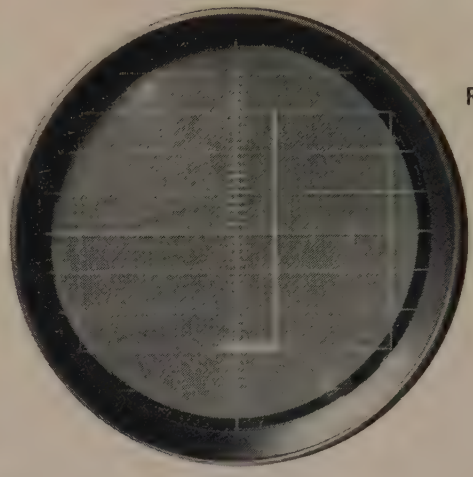


(before) Reverse leakage tracing before immersion in H_2O_2.



(after) Reverse leakage tracing after immersion in H_2O_2, dried without washing (virtually no change).

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To test the effect of impurity-free Becco Hydrogen Peroxide across an unsealed diffused silicon junction diode, the following "tor- ture test" was performed: 600 volts AC were applied across the diode, and the reverse leakage current depicted on an oscillograph. Then, the diode was immersed in Becco 30% Reagent Grade Hydrogen Peroxide. The diode, without being washed in any way, was placed on a hot plate and the H_2O_2 was evaporated.

The voltage was re-applied and the tracing produced was virtually identical (see above)—proof that no impurities that could affect the diode exist in Becco Hydrogen Peroxide.

Of course, you'll use Becco H_2O_2 at a different stage—when you etch the diode. And, of course, good practice still dictates that you wash the diode in pure water following the etch. Nevertheless, this test proves that you need not be too concerned with your wash when you etch in Becco H_2O_2, since the peroxide itself, made by an inorganic method, can not deposit any impurities of its own on the diode.

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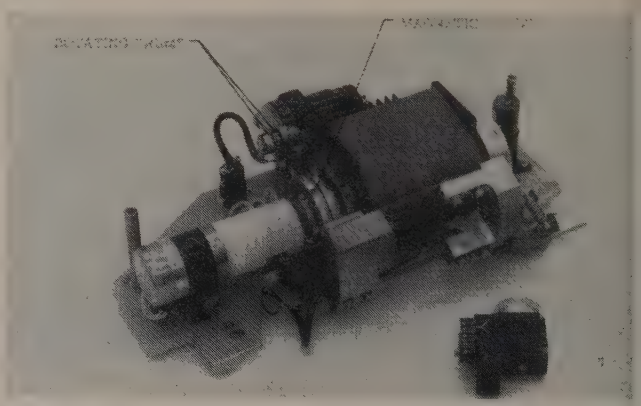
(from page 66)

include their use in devices which pump heat away from high power transistors to a heat sink to make possible considerably higher dissipation rating. This development also enables further subminiaturization of electronic equipment for guided missiles and instruments operating in a critical ambient temperature.

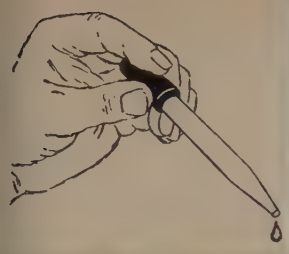
The Ampex Corporation has announced the development of a new wideband recording system. Developed principally for military and scientific applications, there is both an airborne and ground unit. The airborne unit is capable only of recording; the ground unit is a complete recording and reproducing system. Development was accelerated under the terms of a USAF contract. Both units are capable of recording two channels of wideband information over the frequency spectrum from 10 cycles to 4 megacycles. Amplitude response is flat to within 3 db over this frequency range.

Solid-state components and etched circuitry are used throughout the system. This has permitted vast reductions in size and weight. The mobile AR-300 record system displaces 3.5 cubic feet and weighs less than 150 pounds including tape. The FR-700 recorder/reproducer mounts in a standard 19-inch-wide electronics rack and uses approximately 4 feet of rack space for tape transport and electronics. Transistor advances played a significant part in the development of the system and permitted the airborne recorder to fall within the portable category. Ampex engineers contend that without recent transistor progress by various companies, complete transistorization of the system would not have been possible. And this probably would have precluded development of the airborne recorder within the weight limitation established by the Air Force. Shown below is magnetic head assembly common to both units.



Scientists at Bell Telephone Laboratories are developing methods of growing single crystals of a transparent semiconductor, gallium phosphide, and studying its properties. These studies will help in the basic understanding of high energy gap semiconductors. The material is transparent making it possible to observe visually the differences which take place under varying conditions of doping and electron density. Gallium phosphide belongs to the family of semi-conductors referred to as "III-V compounds," which are composed of elements taken from each of the III and V groups of the periodic table. Knowledge gained in studying it should be applicable to other members of this group, some of which are already known to exhibit interesting properties. These include gallium arsenide and indium antimonide, which have shown promise in devices such as point contact and Esaki diodes. Many other III-V compounds have yet to be synthesized.

(Continued on page 70)



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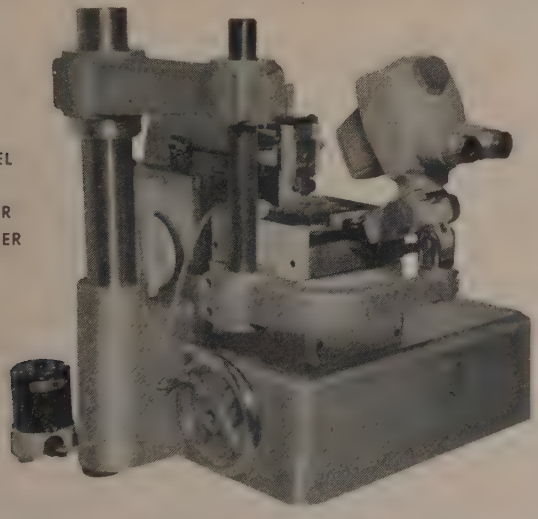

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Industry News (*from page 68*)

A joint effort between the Lansdale Division of Philco Corporation and the F. W. Sickles Division of General Instrument Corporation has resulted in the construction of transistorized TV Tuners having low noise performance superior to presently available TV Tuners and power gain of equivalent value, according to an announcement from Philco. The development of new extremely low noise Philco *MADT* (Micro Alloy Diffused-Base) germanium transistors has made this outstanding tuner a possibility, according to the company. The tuner noise figure varies from a maximum of 4.6 db on the high channels to 3.3 db on the low channels. At the same time, the power gain varies from about 32 db on the high channels to about 45 db on the low channels.

General Electric Company has introduced a new all-transistorized shirt-pocket personal radio communications receiver with miniaturized circuitry that boosts audio efficiency and requires 35 per cent less battery power than previous hand-carried message equipment of its type, according to the company. The new unit weighs only 12 ounces with battery. Although power consumption is reduced, the device is said by GE to have receiver selectivity and receiver sensitivity comparable to mobile radios many times heavier and larger.

A new broad-band microwave amplifier using all solid-state devices was described recently by two Bell Telephone Laboratories engineers. The amplifier makes use of the negative resistance of the Esaki or tunnel diode in combination with non-reciprocal ferrite attenuation in order to achieve a high amplification ratio without self-oscillation. It can be used to increase the strength of radio signals over a broad range of frequencies in the microwave range above 1000 megacycles and is expected to have applications in radar, microwave radio relay, satellite communications, and waveguide transmission systems.

The device is built on a traveling wave concept with a row of Esaki diodes along the center of a strip-line waveguide. It is expected that the frequency of operation of future models can be extended to above 3000 mc, still using germanium diodes. Much higher frequencies, perhaps into the millimeter wavelength range, should be possible with diodes of indium antimonide according to Bell Laboratories.

A completely electronic communication switching center has been designed and built specifically for military field service by the Stromberg-Carlson Division of General Dynamics Corporation. Utilizing the fast-as-light operating speed of transistors and diodes for maximum efficiency and flexibility, this new switching center will provide the high speed communications required by today's modern highly mobile Pentomic Army. The unit is a 200-line "local" switchboard. It accommodates 200 lines to individual terminations, and also has 30 trunks to a long distance switching center, and 50 trunks to other local and tandem switching centers. As many as 60 calls can be handled simultaneously. The local connection can be made by either wire or radio link.

All switching is done completely electronically by solid-state devices, in response to tone signals originating in the transistorized field telephones or mobile radios. Instead of a dial, these field units have a key set, much like an adding machine keyboard, for signaling, providing maximum speed and accuracy.

Book Reviews
(from page 15)

TITLE: Digital Computing Systems

AUTHOR: Samuel B. Williams

PUBLISHER: McGraw-Hill 1959

Digital Computing Systems is a basic introduction to the language, theory, code and equipment of the digital computer. The material stresses the mechanical or relay type of system and actual interface input and output equipment.

The first and second chapters serve to introduce the concept of computing. A historical review, covering the growth of the modern computer, from its early mechanical counterparts, together with a block diagram of the essentials of a computer completes chapter I. The second chapter entitled "Numbers, Letters and Codes" introduces the reader to the basic concept of numbering in systems of different bases. A series of very useful charts show how a decimal may be coded in binary notation, the basic language of computers. In addition the Biquinary (base 5), Teletype Six-unit code with check and Gray Code are tabulated and discussed.

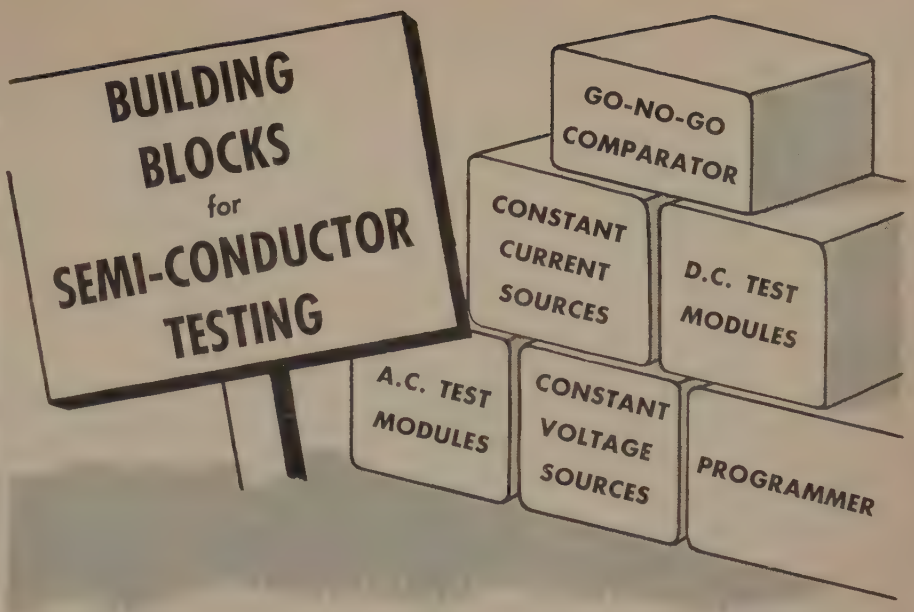
Chapters III and IV discuss equipment or "hardware." The many varieties of input devices or read-in equipments are discussed with excellent descriptions of Teletype, Rem-Rand and IBM equipment to mention a few. In a like manner chapter IV deals with output devices. Again the descriptions of the hardware are quite accurate and lucid.

The next chapter considers storage devices. The usual paper-tape storage is described as is the mercury or "acoustical delay line." More sophisticated techniques and equipment are discussed, such as the "Selectron tube, IBM electrostatic tube, magnetic tapes and magnetic drums. A good description of the magnetic core storage and methods of access may be found. The chapter summarizes by considering other excellent but unusual storage devices capable of storing 64,000,000 characters. An excellent bibliography at the end of this chapter refers the reader to the basic library of devices.

The balance of the book discusses circuits, logic components and programming. Many basic circuits such as the AND, OR, and INHIBIT gates are discussed with both vacuum tube and transistor circuits. Other circuitry including conversion matrices, flip-flops and delay lines are well covered as are a variety of other topics.

Digital Computing Systems is an excellent basic book for the digital engineer. The material covered provides a very excellent introduction to the field and may certainly be considered to comprise a veritable primer course on computers and associated technques.

By Stephen E. Lipsky



Measurements Research Company now offers basic building blocks to those who wish to automate their own testing procedures — as well as completely designed and fabricated "turn-key" installations. Typical of the MRC building blocks are the following modules available in either portable or relay rack configurations:

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D.C. Constant Current Sources: The new model 5909 furnishes 60 micro-amps to 20 milli-amps output at 0-100 volts. Load regulation is better than .1%, line regulation better than ½%. Ripple current less than .1%. Model 5900 offers 1 to 100 milliamps output at 0-100 volts. New models will be announced soon to cover the higher and lower current ranges.

In addition, MRC can provide in modular form equipment for any D.C. semiconductor test parameter normally required as well as A.C. modules at test frequencies up to 250 MC. "Turn-Key" installations include "Hot-Tunnel" diode test sets, Automatic Transistor-Diode Test Sets, Life Test Racks and Wafer Bonding equipment.

For laboratory use as well as low volume quality control testing of transistors and diodes MRC offers the new model 5906 Transistor Tester. This set measures Breakdown, Saturation, Iebo, Icbo, hfe, hfb and Reachthrough. Two current supplies and one voltage supply furnish full scale ranges of .03 to 300 MA. and 0-100 volts.

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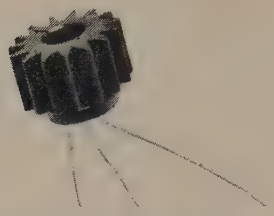

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Market News

Suppliers

Sarkes Tarzian, Bloomington, Ind., plans to enter the Zener diode field shortly. Initial plans call for the production of silicon Zener diodes in three ranges—1 watt, 10 watts and 50 watts. All three will be in full voltage (3-100) range.

Monsanto Chemical Company's Inorganic Chemicals Division, which last year entered the electronic chemicals field with construction of a plant for the production of high purity silicon, has added indium arsenide and gallium arsenide to its line of semi-conductor materials now commercially available to electronic component manufacturers.

Semiconductor services are now being offered by Semiconductor Specialties Corp., 252 Garibaldi Avenue, Lodi, New Jersey on wafering, lapping, dicing, and sizing of semiconductor materials.

Western Transistor Corp., Gardena, Cal., has recently been organized to manufacture and market silicon transistors. The firm has a series of *p-n-p* silicon alloy transistors in production. Plant capacity is approximately 1000 units a day. Plans have been made to go after smaller production quantity orders for specialized devices.

Rheem Manufacturing Co., has formed a new subsidiary, the Rhebo Corp., to develop machinery to automatically manufacture and test transistors, diodes and other semiconductor devices.

General Electric Co., now has available their high speed 2N1289 germanium *n-p-n* transistor for high speed complementary switching.

General Precision Equipment Corp., plans to produce their own transistors in quantities within six months. The firm has established a new company, the Kearfott Semiconductor Corp. in a plant having 9,000 square foot working area in West Newton, Mass.

Expansions

Amperex Electronic Corp., Hicksville, Long Island, New York, a subsidiary of North American Philips Company, announced the acquisition of a new plant located in the Woonsocket Industrial Park in Slatersville, Rhode Island, to be devoted exclusively to large scale production of PADT transistors and semiconductor diodes. Production is expected to begin by September 1, 1960.

Hoffman Electronics Corporation has begun construction of a new Science Center in Santa Barbara. The new 15,000 square foot building which is located on a 10-acre site atop TV Hill, is scheduled for completion in July.

Sylvania Electric Products, Inc., Woburn, Mass., has added 6,000 square feet to its transistor and diode manufacturing operations at Hillsboro, N.H. plant. The company has also leased a 5,000 square foot laboratory and production facility at North Branch, N.H.

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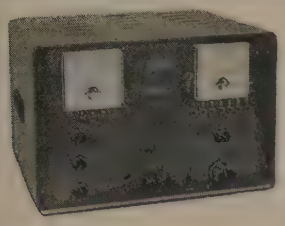

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Pacific Semiconductors, Inc., has acquired an 82 acre site in Torrance, Cal. on which they plan to build a "transistor park" to be devoted to the research, development and manufacture of transistors. When completed, the park will represent an investment of $10 million in land and buildings. This is in addition to the $10 million facilities now being built at Lawndale, Culver City and Hawthorne, Cal.

Prices

General Electric Co. has announced price reductions ranging from 4 to 50% on 39 models of their low current silicon rectifiers. New prices range from 75¢ to $10.30 in large quantities to original equipment manufacturers. The company has also made available two new germanium ultra stable, tunnel diodes, 1N2941 and 1N2969. These are priced at $5.50 each and $6.00 each respectively in production quantities.

Philco Corp.'s Landsdale division has gone into prototype production of its first tunnel diode having a low series inductance and a low series resistance. This unit is presently priced at $10 per unit.

Sylvania Electric Products, Inc., now has available two new p-n-p diffused-base germanium mesa transistors in the milli-micro-second range. Their 2N705 is priced at $16 each in quantities 1-99 and $10 each in quantities 100 to 999. The 2N710 is priced at $13.50 each in quantities of 1 to 99 and $8.35 each in quantities of 100 to 999.

Semiconductor Division, General Instrument Corporation announced major price reductions, ranging from 4 per cent to 75 per cent, on 123 standard types of its medium power silicon rectifiers, used in military, industrial and commercial electronic equipment. Typical reductions, on the seven Joint Army-Navy (JAN) types of silicon rectifiers, used in all types of military electronic gear: JAN IN253, from $1.95 per unit, in quantity lots of more than 100, to $1.85 JAN IN254, from $2.25 to $2.09; JAN IN255, from $3.90 to $3.70; JAN IN256, from $7.40 to $4.47; JAN IN538, from $1.55 to $1.33; JAN IN540, from $2.50 to $2.19; JAN IN547, from $4.80 to $2.80.

Financial

Monsanto Chemical Co., sales for 1959 were $811 million. Assets were reported as being equal to $951 millions.

Hoffman Electronics Corporation's profits in 1959 totaled $1,990,165, up 16 per cent from 1958 earnings of $1,712,509. For the sixth consecutive year, per-share earnings exceeded the prior year. The 1959 per-share profit was $1.31, compared with $1.15 the previous year. Sales climbed to $46,359,832 in 1959, against $39,544,064 the year before—a 17 per cent increase.

Wallson Associates, announced recently the release of 75,000 shares of common stock at $4.00 per share. The company, located at 912-914 Westfield Avenue, Elizabeth, New Jersey, is noted in the electronics field for their test equipment used on semiconductor devices. The equipment is used for the purpose of evaluating and testing the characteristics of these devices for their reliability in operation and life span. Prices vary in these units from $4500 to $36,000.

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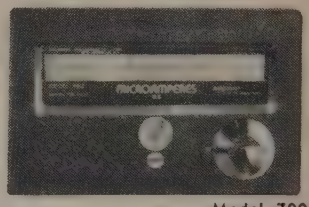

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Philco Corporation has reported a first quarter volume increase of 6.5% over the comparable 1959 period, with sales of $101,781,000 and net income of $1,615,000. Earnings for the quarter were 37¢ per common share after preferred dividend requirements.

The Board of Directors of the Avnet Electronics Corporation voted to recommend to stockholders a two for one stock split. For every share held an additional share is to be issued. To achieve this distribution, stockholders will be asked to authorize an increase in the number of shares authorized from one million to three million and a reduction in par value from ten cents to five cents.

Texas Instruments Incorporated has announced that sales and net earnings for the first quarter of 1960 exceeded those for any previous first quarter in the company's 30-year history. First-quarter sales were $56,198,000 and earnings after taxes and preferred dividends were $3,987,000, or 99¢ per share of common stock on 3,916,921 shares outstanding. These compare with 1959 first-quarter sales of $29,993,000 and earnings after taxes of $2,400,000, or 74¢ per share of common stock on 3,256,988 shares then outstanding.

Transitron Electronic Corporation, one of the nation's three largest semiconductor manufacturers, reports that sales and earnings for the 13 weeks ended March 26, 1960 were the highest in Company history. Sales totalled $13,128,611, compared with $11,829,026 in the previous quarter. Net income for the 13 weeks was $2,154,216, equal to 29 cents per share on 7,502,500 shares outstanding, compared with $2,030,213, equal to 27 cents per share on the same number of shares in the previous quarter.

Sales for the first 39 weeks of the current fiscal year totalled a record $35,113,222, a 62 per cent increase over sales of $21,674,538 for the like period a year ago. Earnings after taxes were $5,961,478 for the 39 weeks.

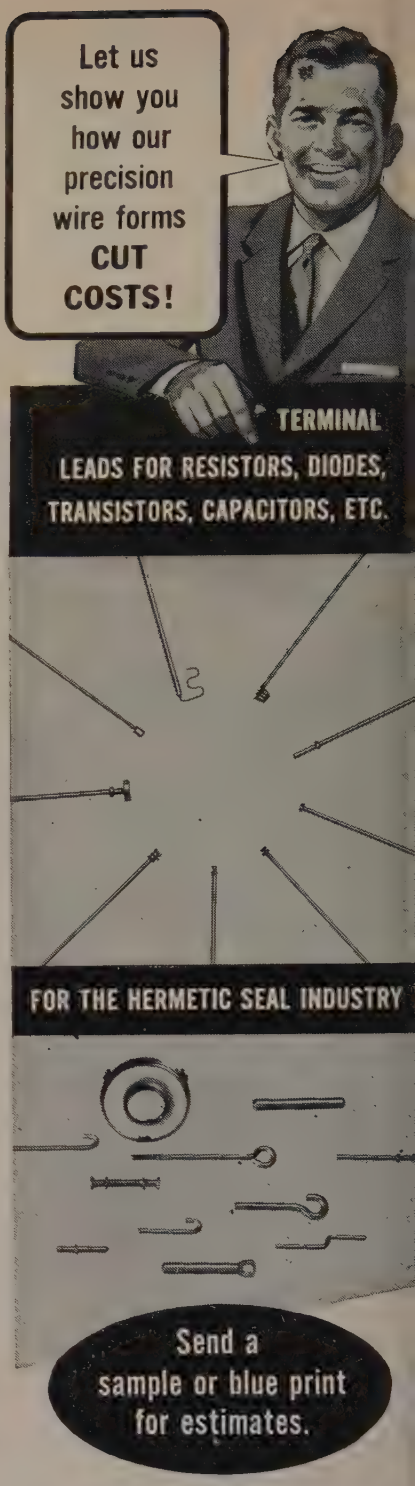
Fairchild Camera and Instrument Corporation has reported the best first quarter in its history, with net earnings after taxes of $801,000, or 77 cents per share for the period ended March 31, 1960. This represents an increase of 108% over first quarter 1959 earnings of $385,000, or 37 cents per share. Figures are based on the 1,039,140 shares outstanding at March 31, 1960.

Sales

According to the Electronics Division, Business and Defense Service Administration, U.S. Department of Commerce, exports of electronic products to the United States from Japan in 1959 totaled $75.6 million or nearly three and one-half times those of 1958. The principal increase was accounted for by radio receivers particularly those having three or more transistors. Of this type 3,900,000 units having a value of $57,270,000 were shipped to the U.S. in 1959.

Export of transistors to this country is listed as follows:

	1957	1958	1959
Quantity in thousands of units	1	11	2,393
Value in thousands of dollars	1	7	1,581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New Literature

Plastic laminated instruction sheet on he use of rhodium plating solutions is ffered by the General Plate Products roup of Texas Instruments Incorporated, letals & Controls division. Designed for ounting on or near the rhodium plating nk for quick reference, the sheet gives structions on making baths for decora- ve and industrial rhodium finishes, and n preparing surfaces for plating.

Circle 100 on Reader Service Card

Sprague has issued their new Engineer- ng Bulletin No. 40,000. This bulletin, a evision of their earlier Bulletin No. 10,- 00, contains general data on miniature ulse transformers and is the first of a ew series of pulse transformer bulletins hich will supersede their present bulle- ins in the 10,000 series. Among the hanges from Bulletin 10,000 to Bulletin 0,000 are the substitution of a typical ransistor blocking oscillator circuit for he electron tube circuit in the older ulletin and the additjon of the com- any's standard method for measuring and-pass characteristics. Please place his new bulletin at the start of the Pulse Transformer" section of your Sprague engineering bulletin binder or le.

Circle 101 on Reader Service Card

Amperex Electronic Corporation has is- ued a catalog, "Amperex Semiconduc- ors," which covers their new complete ine of semiconductors for use in the in- lustrial, communications, and entertain- nent fields. The brochure lists a compre- ensive group of germanium *p-n-p* and *n-p-n* audio, computer, and switching ransistors plus *vhf* transistors for con- erter, mixer, and oscillator applications nanufactured by the new *PADT* (Post Alloy Diffused Transistor) technique. Also listed is a complete list of ger- nanium and silicon diodes.

Circle 102 on Reader Service Card

United Carbon Products Co., is provid- ng a regular monthly newsletter entitled "Breakthrough" which contains sum- naries of the latest developments in the lectronic industry. This monthly news- etter will be sent to anyone interested n the use of graphite jigs, fixtures, boats, ins or other special shapes for use in he semiconductor industry. Short news ummaries cover developments in semi- onductors, electronic components, news rom industry and the military.

Circle 103 on Reader Service Card

Reactive and precious metal tempera- ure characteristics and properties for nu- lear and electronic applications are one f the features of Consolidated Reactive Metals' new pamphlet. Much of the data n these methods, previously available rom many sources, is incorporated in handy reference chart. The pamphlet, mong other things describes the many ypes of mechanical operations which Consolidated can perform to reactive and recious metals to convert them into wire, heet and special shapes for use in nuclear nd electronic fields.

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AVNET•2728 N. Mannheim Rd., Melrose Park, Ill.- GL 5-8160

Circle No. 52 on Reader Service Card

A new three color, 8 page brochure entitled "Requirements for an Ultra Clean Facility" has been made available by Shielding, Inc. The brochure has index tabs for quick reference. The main subject headings are: Construction and Environmental Control Systems. Sub-division discusses: Modular Wall Panels, Non-Dusting Materials, Illumination, Floor Covers, Air-Showers, Pass Through Chambers, Pressurized Cabinets, Temperature-Humidity, Air Pressure, Air Replacement, Filtration, etc.

Circle 105 on Reader Service Card

Dow Corning's recently published 12-page engineering guide explains how various physical forms of silicones contributed to reliability, miniaturization, modularization and environmental protection; increase serviceability over wide extremes of temperature; and aid value engineering. Well illustrated, this "materials handbook" contains engineering data and processing information on silicones, details the important electrical and mechanical properties of the silicones most useful in electronics, describes typical applications for silicones in every area of use.

Circle 107 on Reader Service Card

A new brochure, "Delay Lines—Basic Design Considerations," gives the design engineer the information he needs to calculate the circuit parameters and size of the delay line which will meet his requirements. The booklet also discusses design compromises aimed at reducing size or expense. Copies of the bulletin (#192) are available from Cornell-Dubilier Electric Corporation.

Circle 108 on Reader Service Card

Schweber Electronics is offering a buyers and engineers guide to facilitate the selection of Advance Elgin Relays in the form of a two-color, four page brochure. It is fully illustrated and includes details of application, performance, specifications, etc.

Circle 109 on Reader Service Card

Bulletin 359 issued by Marstan Electronics Corp., is a four-page brochure illustrating and describing one of the company's products of solid state economy series time delay relays for commercial, industrial and military usage. Bulletin PL illustrates and describes the company's products of solid state devices, instruments and components for commercial, industrial and military usage.

Circle 110 on Reader Service Card

James G. Biddle Co. has published "Biddle Instruments," a "briefalog" or digest of their products which is issued every two years. In it the company shows and describes every major line they make or sell. Those desiring complete information on specific instruments can easily obtain carefully detailed bulletins on any of the subjects covered. Request Bulletin 19-60-102.

Circle 112 on Reader Service Card

A variety of miniature and compact refrigeration systems for cooling electronic devices to temperatures ranging from 3.5°K to 200°K. is described in a brochure published by Air Products, Inc. To meet the expanding needs of the electronics industry for refrigeration equipment to operate infrared detectors, masers, irasers, parametric amplifiers and for transistor and superconductor applications, the company has developed and manufactured a wide variety of matched components for refrigeration systems.

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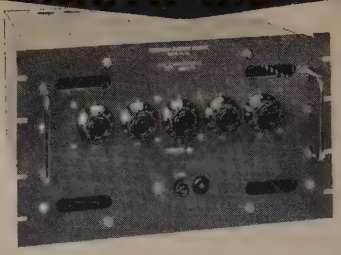
NORTH HILLS'



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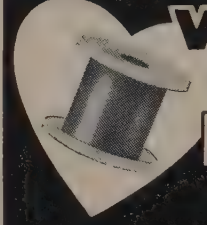

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Personnel Notes

Wilson R. Smith has been named chief engineer, semiconductors, for CBS Electronics, manufacturing division of Columbia Broadcasting System, Inc., in an announcement by Robert G. Marchisio, vice-president and general manager of semiconductor operations. He will be responsible for developments, pilot-line, and product engineering activity.

The J. T. Baker Chemical Company, Phillipsburg, New Jersey, through its President, Dr. J. R. Stevens, announces the appointment of Mr. Frederic W. Hammesfahr as Director of the Commercial Development Department. In his new capacity he will supervise new product commercial development, market research, container research and the handling of technical customer inquiries.

Iden F. Richardson has been appointed a vice president of Hughes Aircraft Company, Lawrence A. Hyland, vice president and general manager announced recently. Mr. Richardson will continue to serve as manager of the company's commercial products activities, a position to which he was named in October of 1959.

Appointment of Alan S. Kumble as product marketing manager has been announced by John F. Hegarty, marketing manager of National Semiconductor Corporation, Danbury, Conn. Mr. Kumble holds a B. E. degree in electrical engineering and a B. S. in industrial engineering from Yale University. He is a member of the Institute of Radio Engineers.

Edward J. Kelly has been named to the new position of Manager of Market Research for Transitron Electronic Corporation. Among his primary responsibilities will be sales, distribution and potential analysis.

The Research and Development Department of General Instrument Corporation's Semiconductor Division announces the following additions to its staff: John Berliner, who has had extensive experience in germanium and silicon diodes and transistors; John Cabot, a specialist in plastics and diode encapsulation; Frederick L. Hunter, Jr., who has had nine years experience in developing silicon and germanium devices; Mrs. Natalie Morozow, specialist in semiconductor materials preparation; Henry C. Schindler, who has had device experience with Intermetallic Compound; Louis Susskind, who is also working in advanced development of devices.

Robert DiMassimo and Vincent A. Ciufia have been appointed Sales Engineers for Rheem Semiconductor Corporation of Mountain View, California it was announced by Dr. E. M. Baldwin, Vice President and General Manager of the silicon mesa transistor, diode, and special assemblies plant. Mr. DiMassimo will work out of the Eastern Regional Office at 610 East Palisade Avenue, Englewood, New Jersey. Mr. Ciufia has offices at 1919 N. Harlem Avenue, Chicago 38, Illinois.

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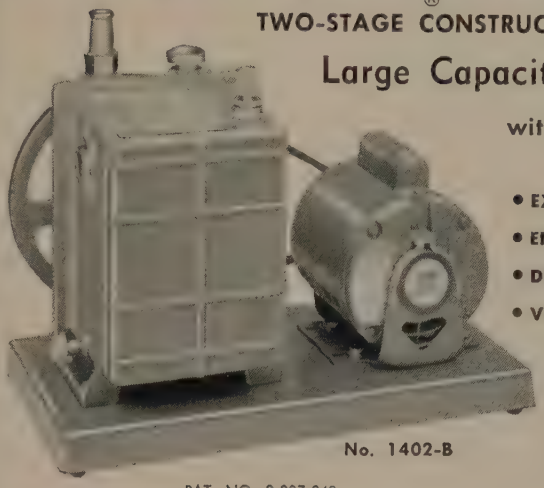

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John F. Gilbert has been appointed distributor sales manager of semiconductor operations of Philco's Lansdale Division, it was announced by William F. Maher, manager of sales. Mr. Gilbert will manage the division's distributor organization, comprising 61 selected industrial distribution outlets across the country situated near all leading industrial areas.

Dr. John J. Draney has been named vice-president in charge of the newly created Chemical Products Division of Alloys Unlimited, Inc., Long Island City. In his new position, Dr. Draney will supervise the development and production of chemicals and intermetallic compound materials for the semiconductor and related electronic industries.

The appointment of J. Robert Henderson to the newly created position of manager of packaging engineering for the Semiconductor Division of Sylvania Electric Products Inc., has been announced by Dr. J. Earl Thomas, director of research and engineering for the division. In his new assignment Mr. Henderson will have overall responsibility for the design, processing and functions of transistor, diode, and rectifier packages as well as industry coordination and acceptance.

Dr. Samuel M. Fok has been appointed to the technical staff of Fairchild Semiconductor Corporation's Research and Development Laboratories, Dr. Gordon Moore, Research and Development head, announced recently.

Appointment of George J. Feder as Manager, Somerville Operation Services, for the RCA Semiconductor and Materials Division was announced by K. M. McLaughlin, Manager of the Division's Computer Products and Materials Department.

Dr. R. W. Guard has been appointed Manager—Product and Process Development Engineering, Diamond Products Section, Metallurgical Products Department, General Electric Company, Detroit, Michigan. Dr. Guard will spearhead G. E.'s expanding program to develop new diamond products for use in a much wider range of applications, as well as new products of superpressure technology.

Dr. Morton B. Prince, a pioneer in the semiconductor field, has been appointed vice president and general manager of the Semiconductor Division of Hoffman Electronics Corporation. He succeeds Maurice E. Paradise, who has been named to the new position of corporate vice president in charge of product planning.

Jacob Maechtlen has been appointed Assistant to General Manager W. R. Sittner of Sperry Semiconductor Division of Sperry Rand Corporation at South Norwalk, Connecticut. This division is a leading manufacturer of high-quality silicon diodes and transistors.

It is with the deepest regret that we announce the passing of Mr. Abe Jaffe of Wallson Associates, Elizabeth, New Jersey.

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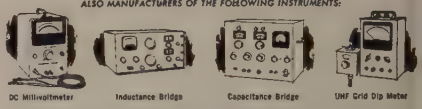

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INDEX TO ADVERTISERS

Accurate Specialties Company, Inc.
Aeroprojects Incorporated
Aerotronic Associates, Incorporated 14
Ajusto Equipment Company ... 68
Allegheny Electronic Chemical Company
Allied Chemical Corporation General Chemical Division ... 10
Allied Radio Corporation
Alloys Unlimited Incorporated .. 6, 7
Alpha Metals, Incorporated 23
American Optical Company 64
Art Wire & Stamping Company 74
Avnet Corporation 76

BTU Engineering Corporation
Baker, J. T. Chemical Company
Becco Chemical Division Food Machinery & Chemical Corp. 67
Bendix Corporation, The Red Bank Division 12
Birtcher Corporation, The 72
Boonton Electronics Corporation 78
Brinkman Instruments, Inc.
Bronwill Division of Will Corporation
Burke & James, Incorporated

CBS Electronics 18
Cambridge Communications Corp. 67
Charleston Rubber Company
Cohn, Sigmund Corporation
Conforming Matrix Corporation
Consolidated Mining & Smelting Company of Canada 66
Consolidated Reactive Metals, Inc.
Consultants Bureau Enterprises 77
Custom Scientific Instruments, Incorporated

Davison Chemical Company Division of WR Grace
DoAll Company, The
Dow Corning Corporation
Duramic Products, Incorporated
Dynatran Electronics Corporation 73

Eagle-Picher Company, The
EICO
Electro Impulse Laboratory ... 63
Electro Instruments, Inc. 22
Electronic Laboratory Supply Company
Electronic Research Associates
Elgin National Watch Company Abrasives Division
Epoxy Products, Incorporated

Fairchild Semiconductor Corporation 2, 3

Gasket Manufacturing Company
General Electric Company Lampglass Division 62
Semiconductor Products Department 68, 70
General Instruments Incorporated
Glass Beads Corporation
Grace Electronic Chemicals Inc. 8
Graphic Systems
Greibach Instruments Corporation 73

Hayes, C. I., Incorporated 78
Hevi-Duty Electric Company
Hickok Electrical Instrument Company, The
Hoffman Electronics Corporation Semiconductor Division 1
Hughes Aircraft Company
Hunter Tools Company

Indium Corporation of America, The
Industro Transistor Corporation
Instant Circuits
Institute of Radio Engineers
International Business Machines 24

JFD Manufacturing Company, Inc.
Johnson & Hoffman Manufacturing Company 65

Kahle Engineering Company ... 26
Kanthal Corporation, The 66
Kessler, Frank Company, Inc.
Knapic Electro-Physics Incorporated ..... **Cover III**
Kulicke & Soffa Manufacturing Company, The 69

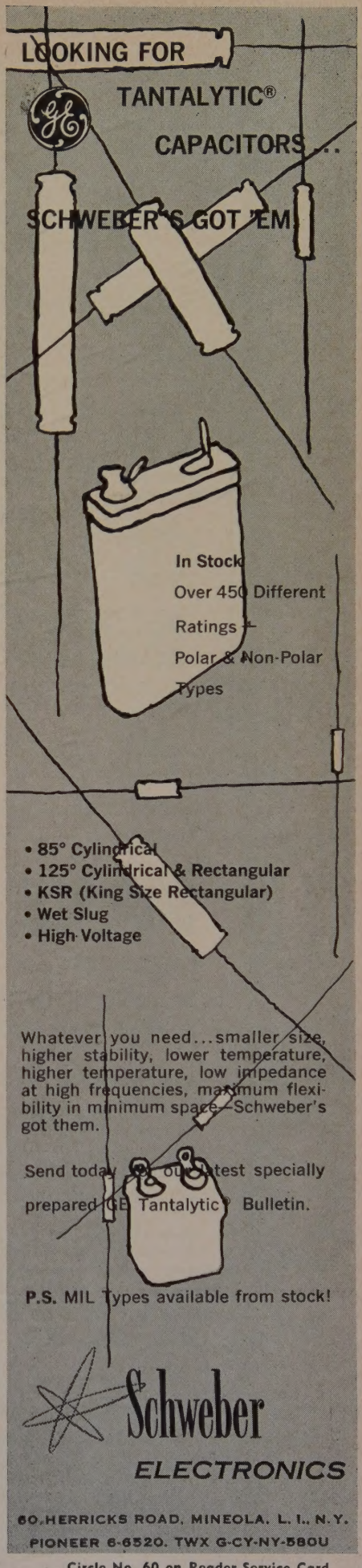
L & R Manufacturing Company
Labline, Incorporated
Lafayette Radio 80
Lepel High Frequency Laboratories
Lindberg Engineering Company

McCall Tom & Associates, Inc.
Manufacturers Engineering & Equipment Corporation 69
Measurements Research Company 71
Merck & Company, Incorporated Electronic Chemicals Division 4
Micromech Manufacturing Corporation 13
Milgray ..... **Covers IIA & IIB**
Minneapolis-Honeywell Boston Division
Monsanto Chemical Company .. 19
Mueller Electric Company

Narda Ultrasonics Corporation
National Findings 78
Newark Electronics Corporation
New York Air Brake Co., The Kinney Manufacturing Division 15
North American Electronics, Inc.
North Hills Electronics, Inc. 76
Norton Company

Ohio Carbon

Continued on next page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INDEX TO ADVERTISERS

(Continued)

Penfield Manufacturing Company, Inc.
Pereny Equipment Company ..
Philco Corporation Lansdale Division .....
Pitt Precision Products, Incorporated .....
Pure Carbon Company, Inc. ...

Radio Receptor Co., Inc. General Instrument Corp. ....
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Rheem Semiconductor Corporation

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Schweber Electronics .....
Secon Metal Company .....
Semi-Alloys, Incorporated
Semimetals, Incorporated .....
Sprague Electric Company Cover I
Sperry Rand Corporation
Sylvania Electric Products, Inc. Chemical & Metallurgical Div. Parts Division ..... **Cover**
Semiconductor Division

Tang Industries .....
Tektronix, Incorporated .....
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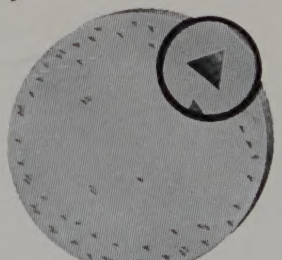

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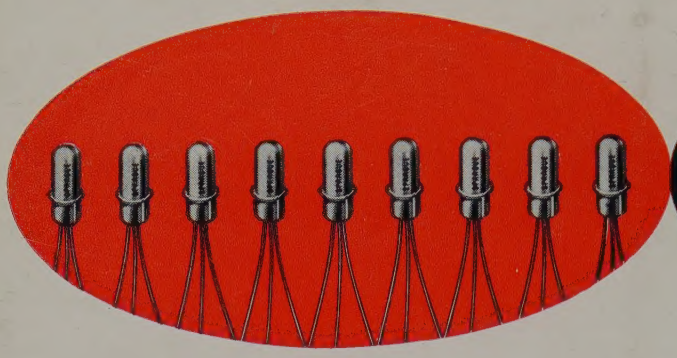

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